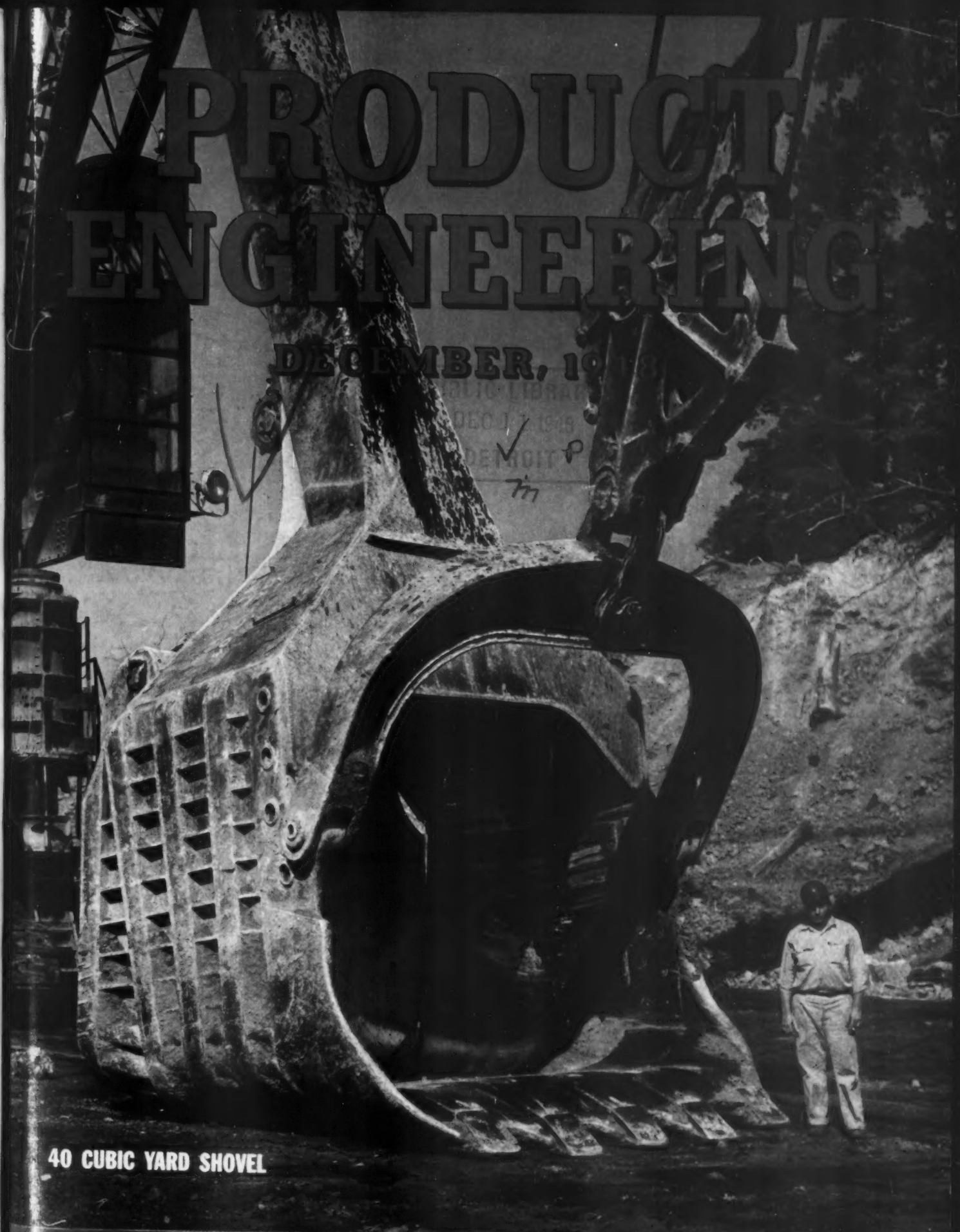

40 CUBIC YARD SHOVEL

IN THIS ISSUE — Design of Giant Shovel + Adjustable Speed Drive Analysis + Control of Engineering Projects + Dimensional Relationships + Disk Cams + Electroforming

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INCO OFFERS EXPERIENCED COUNSEL ON METAL PROBLEMS

Avail yourself of experienced counsel on problems relating to the properties, treatment, fabrication or performance of ferrous and non-ferrous metals containing nickel.

We offer consultation . . . and invite you to write, wire or phone the INCO Technical Field Section or Stock and Service Center nearest to your plant.

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VOLUME 19

PRODUCT ENGINEERING

NUMBER 12

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DECEMBER 1948

Why Consider an Adjustable Speed Drive 81
Analysis of variables that affect optimum operating speeds of machinery.

Electroforming Difficult Shapes by W. H. Prine 86
An economical solution for the construction of many complex forms and surfaces.

Product Designs 90
Marion shovel, Sprinkler system, Meter adjustment, Safety clutch, Impact press, Hydraulic press.

Engineering Scheduling and Control by G. D. Kirtland 102
Discussion of scheduling and control fundamentals. Use of visual control board.

Four-Bar Linkages and Applications 106
Twenty-four examples showing how this basic mechanism is used in engineering practice.

Bearings and Lubrication for High-Speed Machinery by R. W. McLaughlin 108
How to select and lubricate journal bearings for heavy, high-speed machinery.

Permanent Magnet Stability—II by R. J. Studders 113
Effects of mechanical shock, impact, vibration, and reluctance changes in the magnetic circuit.

Hydraulic System Testing by Leo M. Chattler 119
New electronic equipment permits detailed study of instantaneous transient pressures.

Thermosetting Plastic Laminates—I by Norman A. Skow 123
First of a series describes base materials and resins in standard grades, giving NEMA designations.

Extruded Aluminum Propeller Blades and Hub by Walter H. Korff 127
A new approach yields a method for making metal propellers lighter and less expensive.

Accelerations by Vector Methods in Disk Cam Mechanism by Jesse Huckert 128
Analysis carried out for a mechanism in which all the motion occurs on the follower.

Determining Dimensional Relationships in Complex Parts by Charles H. Buccola 133
A method of analyzing dimensional relationships algebraically to improve ease of production.

Nomograph for Designing High Speed V-Belt Drives by K. D. Lewis 155
Chart and equations for rapid determination of belt speed and tension.

Metal Finishing Process Information Sheets—III by George Black 159
Compilation of four different processes used in preparing and finishing aluminum and its alloys.

INDEX TO VOLUME XIX FOLLOWS PAGE 146

DEPARTMENTS

FRONT COVER—Forty cubic yard alloy steel dipper increases capacity of Marion's stripping shovel. Kodachrome courtesy Marion Power Shovel Co.

Highlights 3
Editorial 79
Engineering Abstracts ... 137
Technical News 141
Washington Notes 143
New Materials and Parts. 161
New Books 174
Our Readers Say 180

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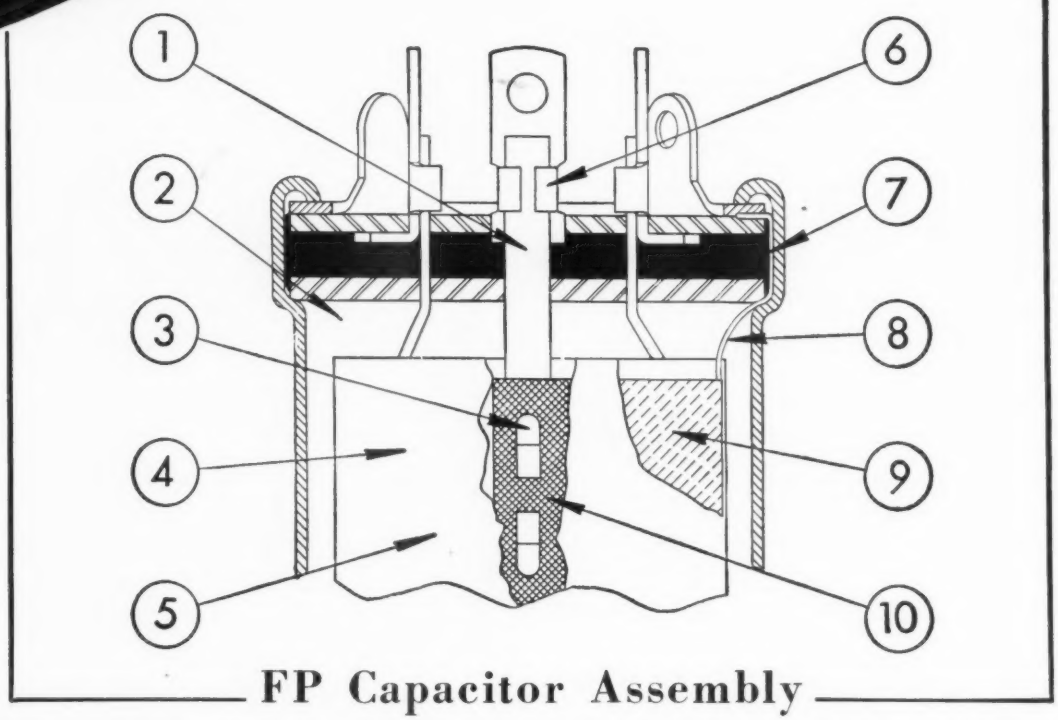
NEW!



FP Capacitor Assembly

For the past ten years Mallory FP Capacitors have set new standards of dependability. Now new improvements make them more reliable than ever.

1. *New design anode tabs cannot break from vibration.*
2. *Ample air space retained for gas expansion at elevated temperatures.*
3. *New staking method between anode and tab permits higher discharge currents.*
4. *Improved high surge separator material better at high temperatures.*
5. *Unique processing improvements provide still better performance at 85°C. No voltage derating required by Mallory FP capacitors at this temperature. (Including the 450V rating.)*
6. *Lower tab to terminal contact resistance for sensitive circuits.*
7. *Extra heavy rubber seal for high temperature and ripple conditions with venting feature preserved.*
8. *Heavier cathode tab for better tab to ring weld, lower resistance and more rugged mechanical construction.*
9. *Special etched cathode (all voltages) reduces loss of capacity under high ripple conditions, lowers RF impedance and remarkably reduces intersection coupling.*
10. *Increased FP anode ratio of 12 to 1 at 450V and 15 to 1 at 150V provides better design factors.*

Still cost no more. **Mallory FP capacitors have given exceptional performance at prices comparable to ordinary capacitors. These new improvements have all been accomplished without extra cost to the user.**

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Send for the Mallory Capacitor Catalog, which contains useful data on all types of Mallory Capacitors—sizes, electrical characteristics, test measurements, mounting hardware.

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(ELECTROLYTIC, OIL and WAX)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

METALLIC MATERIALS

AUSTENITIC STAINLESS STEEL containing approximately 21 percent chromium and 12 percent nickel has proven most suitable for exhaust valve heads. Material withstands corrosive action of exhaust gases, does not harden from repeated heating and cooling and is highly ductile.

PURE TITANIUM is finding increased usage as an engineering material. With properties generally intermediate to aluminum and steel, the metal in the annealed state has a tensile strength of 80,000 psi, a density of 4.54 and a melting point of 3,140 F. Limited quantities are made in sponge and ingot form.

LITHIUM has come into wide use in the form of metal, salts or alloys. It is being applied in pyrotechnics, welding and ceramics, as a grease for airplane engines and for the removal of oxygen from heat-treating furnaces.

MANGANESE IRON PHOSPHATE crystals applied to Dodge engine cylinder walls form an oil-absorbing coating that permits driving at 40 mph and higher during the break-in period.

A TOUGH, HARD ALLOY STEEL called Hy-Tuf will absorb 27 percent more stress and has greater impact resistance than conventional construction steels of equal toughness. Material can be annealed and both flash and arc welded.

PISTON RINGS centrifugally cast from K-spun fine-grained, martensitic cast iron are being used as top compression rings in Diesel and gasoline engines. They are claimed to have a combustion shock resistance four times that ordinarily exhibited by standard rings, thus reducing breakage during service.

ANTIMONY TRIOXIDE contained in the coating material of fluorescent lamps has doubled their operating life to 4,000 hr and a special heater coating retards two types of discoloration known as "end band" and "anode spot."

NONMETALLIC MATERIALS

BAKING ENAMEL for reflector panels of light fixtures has a reflectivity of 87 percent. Called Codur Glass 6808, finish is highly resistant to moisture.

THE VAPOR from a silicon derivative liquid is being applied to radar insulators, windshields and camera lenses as a water repellent. The sub-microscopic film produced causes water to form beads between which high frequency currents are unable to jump.

SMOOTH, RIGID VINYL SHEET can be marked with a lead pencil and then cleaned like a blackboard. Sheets in various thicknesses to ⅛ in. are dimensionally stable and come in standard colors, either opaque, translucent or transparent.

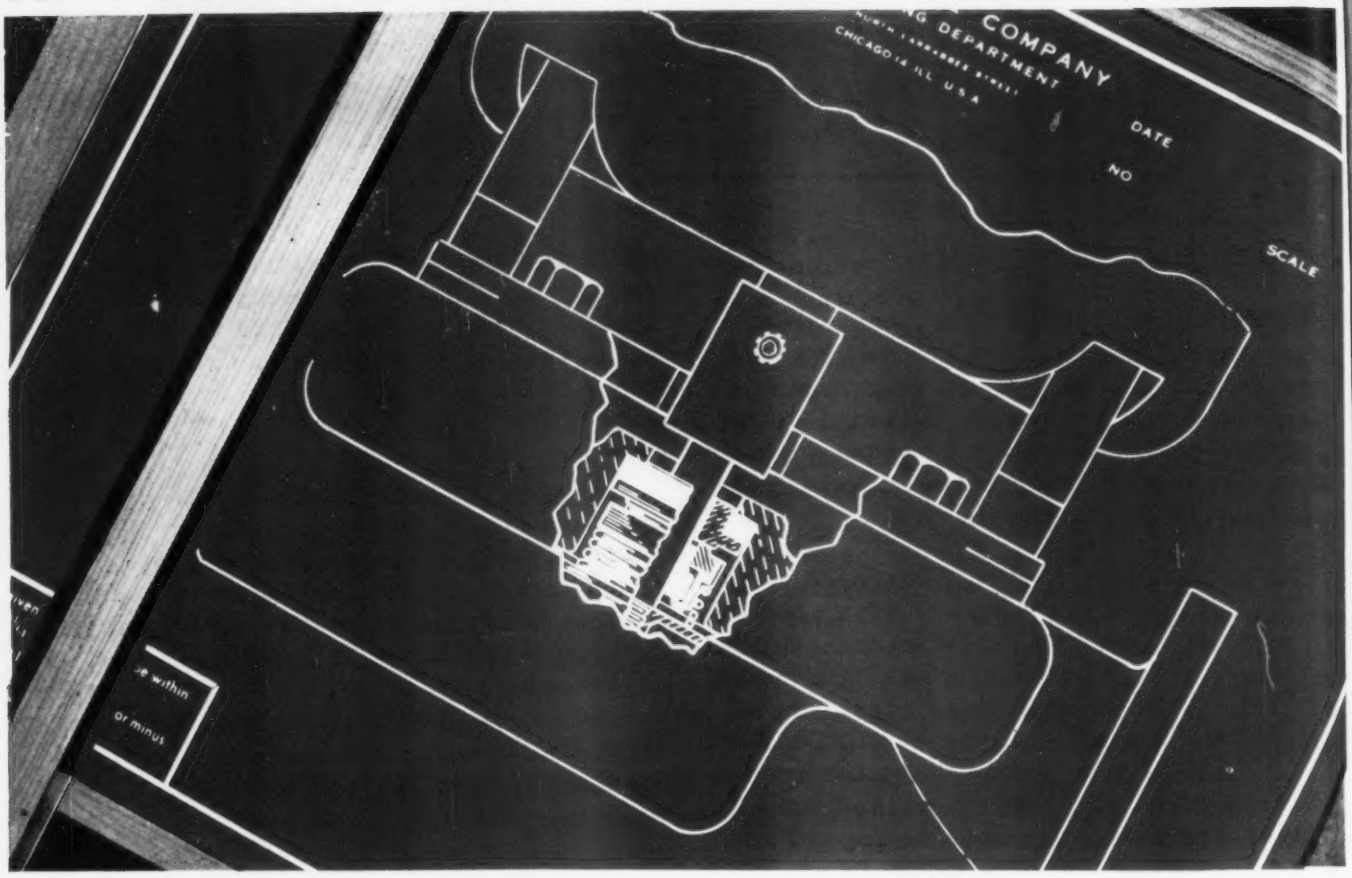
A CORROSION INHIBITING COMPOUND, RD-119, lengthens the life of the metal components in fuel systems. When added to fuel in ratio of 1 pint to 2,000 gal, inhibitor forms a protective coating that resists air and moisture.

A BLEND OF SYNTHETICS--rubber and resins--is taking the place of wood in applications where impact resistance is important. Material is called Kralite.

ASBESTOS-BASE electrical tape insulation called Quinterra maintains a dielectric strength of 300 volts per mil up to the annealing temperature of copper. Noninflammable and inorganic, material has

Continued on Page 5

THIS BUILT CERTAINTY INTO A CIRCULATOR—



and ROTARY SEAL can make *Your* seal *sure*

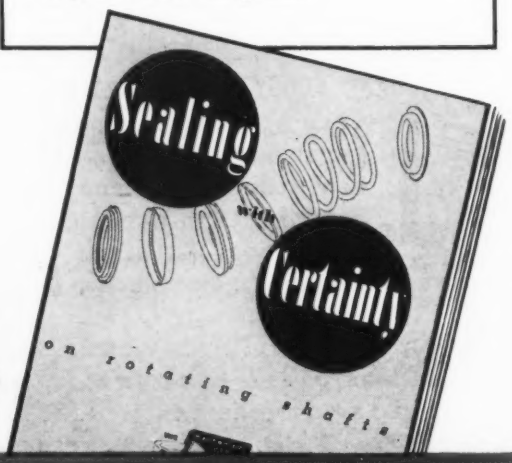
A "booster" just won't boost properly without a sound shaft seal—one that removes *all* uncertainty from performance throughout the life of the unit. Rotary Seals provide just that assurance, not only for circulators but for all the many types of equipment with which positive shaft-sealing is of prime importance.

You see, Rotary Seals are "tailor-made" to fit the specific needs of each application. You don't have to juggle a stock part or assembly to try and make it fit; expert engineering assures you that the patented Rotary Seal principle will be provided in a form which exactly meets your requirements. That way, you're sure of maximum efficiency, reduction of maintenance and repair expense, and trouble-free performance in actual use.

We believe Rotary Seal engineers can save *you* time and money, too—call them in on the first steps of your project!

THE ROTARY SEAL PRINCIPLE

is explained and illustrated in detail in our booklet, "Sealing with Certainty on Rotating Shafts". You should have this information—we'll be glad to send it to you without obligation.



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mechanical seals for rotating shafts

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a structure without holes and interstices and is available in thicknesses from 1.5 to 20 mils.

FOLDING GLASS panels are replacing the narrow rear vision strip used in convertible automobile tops. Full vision as in stock model cars is provided by plate glass plastic sandwich sections that fold like an accordion on a ¾ in. plastic joint when top is lowered.

TWO GRADES OF POLYSTYRENE have improved heat resistance qualities. Styron 637 has 4 to 5 times the regular color permanence, while Styron 475 has 3 to 5 times the impact strength of standard grades. The latter fills the gap existing between rigid, dimensionally stable polystyrene and tough cellulosic-derivative plastics.

THERMAL BARRIER, SEALING COMPOUNDS, Stabond FR-8 and FR-10, will resist temperatures up to 2,000 F. Maximum resistance to air and flame abrasion is obtained by adding such materials as perforated glass cloth. Applications include electrical junction boxes, heat exchanger couplings and hot air ducts.

ELECTRICAL INSULATING PAPER used between aluminum foil windings in large capacitors is only 0.0002 in. thick. Made of wood pulp that is beaten in water until fibers are broken into microscopic fibrils, material is also being considered for small electronic components.

DICHLOROSTYRENE-BUTADIENE is being used in place of styrene-butadiene in GR-S formulations containing zinc oxide for use in white side-wall tires. Rubber has improved tensile strength and tear resistance.

HYDRAULIC FLUID that will not burn when subjected to a 5,000 F flame has been announced by Standard Oil of Calif. Product is stable in temperature range from -70 to +250 F and can be used in systems operating at pressures up to 3,000 psi.

PROCESSES

SPECIALLY SHAPED ANODES are being used when recessed parts are electroplated. Shaped to fit the contours of the part being plated, the electrode is insulated from both anode and cathode. Through dipolar action, the throwing power of the current is increased, and a plating of uniform thickness is produced.

A NEW LOOK IN PLASTICS is being produced by a molding process that incorporates a design printed on resin impregnated paper in flat plastic surfaces. Design looks like a decal but does not wear off with use.

A DECORATIVE FINISH FOR ALUMINUM can be produced by the electrodeposition of various metals. Chromium is used to improve abrasion resistance while silver is applied to improve electrical contact. Copper, brass and tin plates are usually used where soldering operations are required and black nickel gives an attractive background for items such as nameplates. Zinc plate is anodic to aluminum and therefore offers corrosion protection.

MOLLERIZING, a process developed in Sweden for impregnating the surface of steel with aluminum, is said to afford a rust resisting surface which can be anodized and colored in the same manner as can aluminum alloys. The impregnating is done in a bath composed principally of barium chloride on which is floated molten aluminum.

EXTRUSION OF THIN-WALLED PLASTIC TUBING to a dimensional tolerance of 0.001 in. is accomplished by adding a cooling sleeve to the standard extrusion die. An 8 in. sleeve, with bore etched to a matte surface, is used for making 1⅛ in. diameter tubing at a rate of 80 lb per hour.

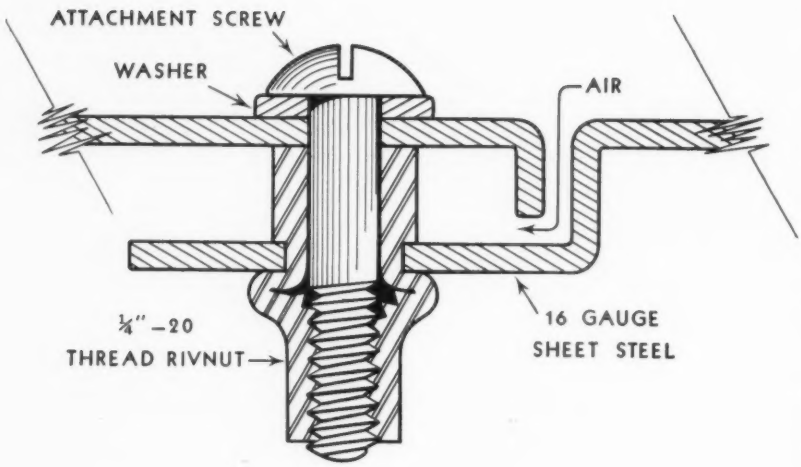
EQUIPMENT

50-TON SELF-PROPELLED ROAD SCRAPERS are being powered by 12-cylinder Allison aircraft engines. Power ratings are reduced to 600 hp to permit economical operation on butane fuel.

HEAVIEST SHORT CIRCUIT ever recorded, 9,600,000 kva, was interrupted by a circuit breaker in tests at Grand Coulee.

Continued on Page 7

New ¼" RIVNUT solves tough fastening problem—replaces three parts



Designers of a new bus engine came up against a tough fastening problem in providing an air vent between two steel sheets of the engine housing. Because it was a semi-blind fastening job, the use of conventional bolts, nuts and spacers would slow production.

They found the answer in spacer-head Rivnuts. The ¼" steel Rivnut was inserted in the 16-gauge sheet steel and upset with power tool by *one* man, working from *one* side. The increased Rivnut head served as a spacer for the second steel sheet, which was firmly anchored by an attachment screw, threaded into the Rivnut.

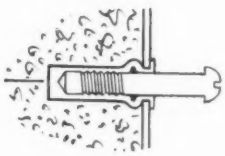
The ¼"-20 thread Rivnut provided extra strength, improved the design and cut costs. If you're faced with a fastening problem, why not call in a Rivnut engineer? Write the B. F. Goodrich Company, Dept. PE-128, Akron, O.

What's your toughest fastening problem?

TORQUE?

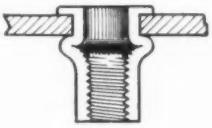
Special Rivnuts with splined shafts or key (above) supply needed torque resistance.

SEAL?



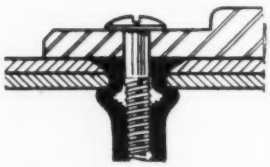
Firm grip of upset Rivnut on material, plus special closed end, gives tight seal.

MATERIAL?



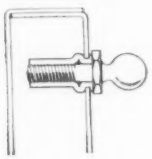
Even in thin materials, Rivnuts provide a secure nut plate with eight clean threads.

ATTACHMENT?



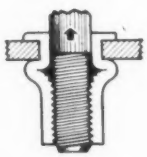
Rivnut serves both as blind rivet and nut plate, makes possible multiple fastening.

FINISH?



Rivnuts can be installed *after* finish, such as paint or porcelain, is applied.

LOADS?



Typical Rivnut thread strength: 6-32—784 lbs.; 8-32—1101 lbs.; 10-32—1220 lbs.*

RIVNUTS *lick them all!*

**Figures given for aluminum. Loads for brass and steel Rivnuts about double.*

B.F.Goodrich

RIVNUTS

It's a rivet—It's a nutplate

GET YOUR COPY OF NEW RIVNUT DATA BOOK

Just off the press! New edition tells how to install Rivnuts. Includes facts on new heading tools, test data. Gives types, sizes and grip ranges. For your free copy, write to the B. F. Goodrich Company, Dept. PE-128, Akron, O.

The breaker cleared the short circuit in less than 1/20 sec, and is capable of clearing, reclosing and then re-opening, if short circuit is permanent, in less than ⅓ sec. Moving contacts on the breaker reach a speed of 20 ft per sec in only a few inches of travel.

CONTINUOUS-FLOW FUEL SYSTEM automatically supplies fuel to all engines on large aircraft. It also permits rapid refilling of all tanks from a single, accessible location on the airplane. In case of powerplant failure, fuel for the inoperative engine can be manually shut off.

MINIATURE WIND TUNNEL that simulates flying conditions of 1,260 mph at 80,000 ft is 20 ft long and has test sections one by two inches. Enclosed air stream system cleans and drys air while returning it for reuse.

30-TON ROTARY PRESS with 12-station head will produce 65 to 91 powdered metal parts per minute. Parts up to 2½ in. in dia with a die fill of 4¼ in. can be accommodated.

TURBINE BLADE FATIGUE TESTER subjects specimens to two types of loading at once. Machine applies alternating flexure loads up to ± 1,350 lb at rate of 3,600 cps and tensile loads up to 8,000 lb. Blades heated to 1,800 F can be tested.

A MOBILE BETATRON that will produce 10-million-volt X-rays can "look through" 16 in. of steel and study complex internal assemblies. X-ray shadowgraphs show stresses and shocks developed in the material.

RECTIFIED A-C ALTERNATORS for 6- and 12-volt electrical systems on automotive and Diesel engines will deliver maximum outputs up to 80 and 150 amp. Simplified design has no commutator, brushes or rotating armature winding.

MISCELLANEOUS

BETWEEN 1930 and 1948, increases in octane number of fuels spearheaded rise of compression ratio in automobile engines. According to GM researchers, the order is reversed today. About one half of fuel economy gains during last 18 years were result of increased octane number; remainder attained through refinements in engineering design. Further gains up to 50 percent are expected when fuel and engine researchers arrive at octane number and compression ratio goal. The Oldsmobile Division is getting ready to start production on a 7.25 to 1 compression ratio V-8 engine for 1949 Models.

AUTOMATIC WEATHER STATIONS that will send radio reports on temperature, pressure, and wind speed are under development by the Signal Corps. A wind-driven generator charges batteries that power the recording equipment. A 24 mph wind will produce a generator output of 2.5 kilowatts.

ELECTRONIC COMPUTER will solve initial valued differential equations up to the seventh order. A servo mechanism can be attached to provide for vector resolution and addition, and special potentiometers permit multiplication and division of arbitrary functions.

FRICTION in the present gear of the 200 in. telescope atop Mt. Palomar, although amounting to only 1.3 percent of the weight supported, impairs the optical performance of the instrument. Three decades ago it took a year and a half to adjust a 100 in. telescope; another 8½ years to bring the lag of its supporting system within limits. Considering the 5,600 ball and roller bearings, the 36 counterbalancing units, and the 1,100 precision parts, work at Mt. Palomar is making astonishing progress.

RETRACTIBLE SKI GEAR has been installed on a Fairchild C-82 cargo plane. It can be raised or lowered in relation to the plane's standard wheels.

POLE TIPS for the magnets of the new 400 million volt synchro-cyclotron now being built by Carnegie Tech will enable operation at a magnetic field beyond that obtained in other cyclotrons. Pole tip faces have hills and valleys machined in them to increase useful pole radius.

G-E SILICONES FIND THEIR PLACE IN THE SUN

How G-E Silicones can help you

Can your product or production methods be improved by the use of chemically inert, high- and low-temperature-resistant materials? Then it's very likely that General Electric silicones are just what you are looking for.

For example, recently an architect has found that G-E silicone rubber serves as an excellent gasket for cushioning large double-sheet plate-glass windows in ranch-style houses. This unusual silicone product retains its resiliency despite constant window pressure . . . despite long exposure to snow, rain, ice, and moisture. And in addition to withstanding temperature extremes, a G-E silicone window gasket will not harden, crack, or rot. It is even resilient enough to be set in the irregularities of a concrete foundation and still give positive sealing!

Something New in Finishes!

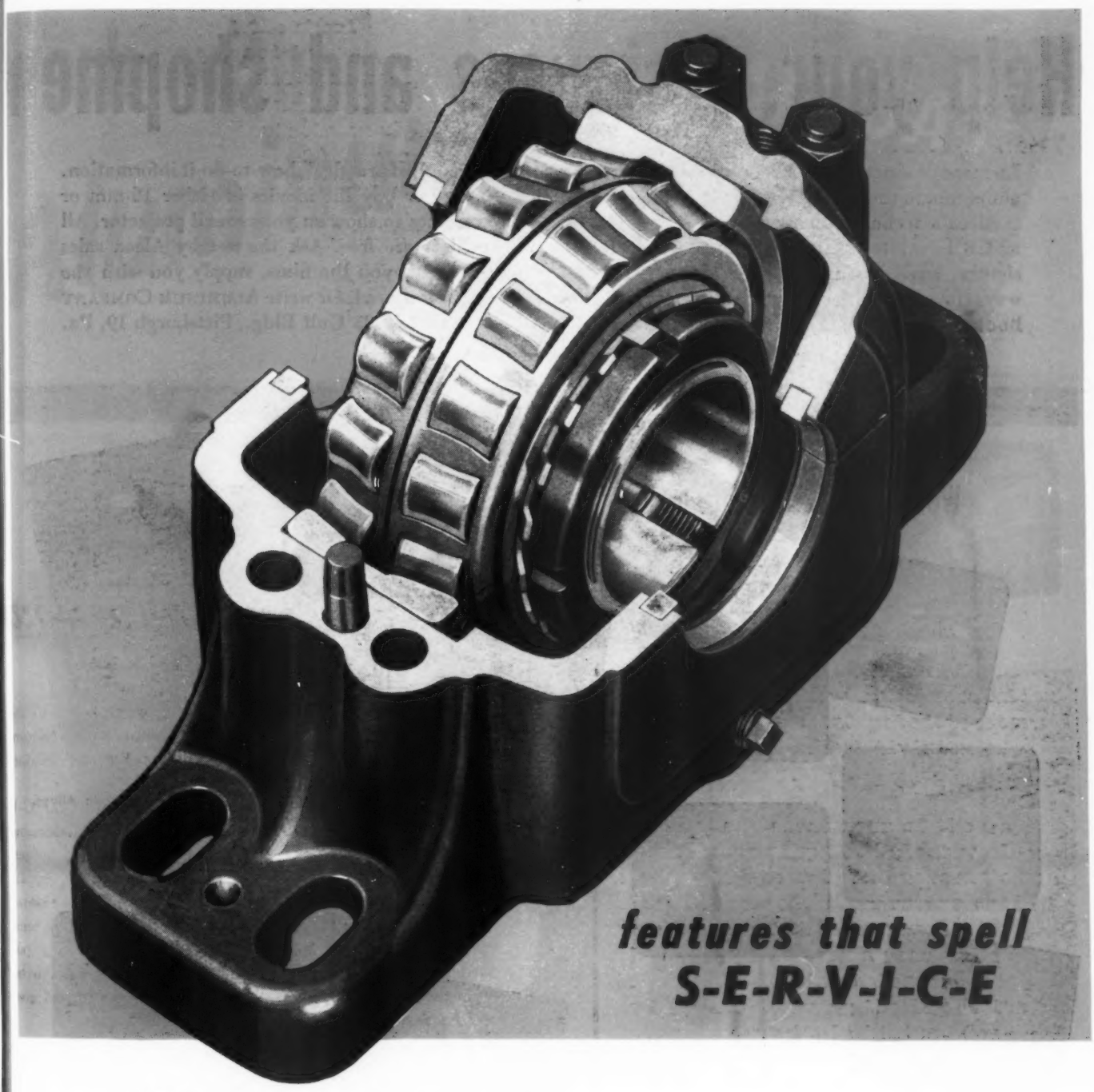
Have you heard about G-E silicone *resins*? When available for synthetic enamels for kitchen ranges, automobiles, and other products, silicone resins will make possible a remarkable finish . . . one with characteristics of durability and sunfastness never before achieved!

WANT TO KNOW MORE ABOUT G-E SILICONES? You can find out how these amazing materials may fit into your own production picture by simply contacting us. Chemical Department, General Electric Company, Pittsfield, Massachusetts.

GENERAL ELECTRIC

CD48-Q10

SILICONES for Industry



Self-aligning, free-rolling action

Effective seals keep grease in, dirt out

Radial-Thrust load capacity is high

Various mountings for all applications

In stock at all industrial centers

Compact, sturdy housings require minimum space

Economical, efficient and dependable operation

LINK-BELT COMPANY Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 11,308

LINK-BELT *Ball and Roller BEARINGS*

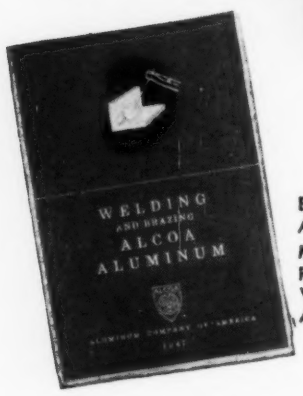
Help your designers and shopmen wo

Increase production, cut production costs by using aluminum to the best advantage in your products.

Alcoa's technical library of 11 sound movies and 8 booklets is available to show your designers, engineers and production men the best ways to work with aluminum. Each film and book was produced by an Alcoa specialist. They're full of practical, how-to-do-it information.

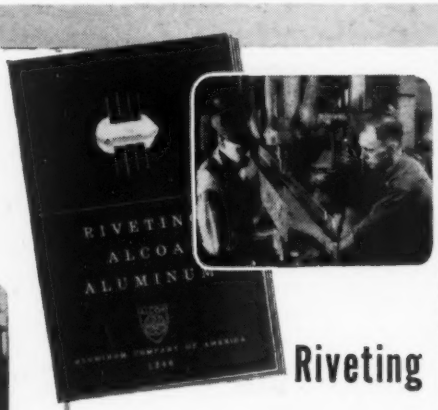
Borrow or buy the movies in either 16-mm or 35-mm sizes to show on your sound projector. All 8 booklets are free. Ask the nearby Alcoa sales office to lend you the films, supply you with the booklets you need. Or write ALUMINUM COMPANY OF AMERICA, 2193 Gulf Bldg., Pittsburgh 19, Pa.

Welding and Brazing



Booklet: Welding and Brazing Alcoa Aluminum, 128 pages.

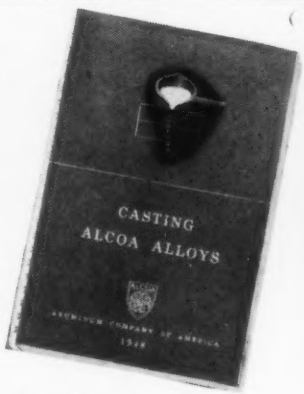
Movies: Arc Welding, 10 min. Resistance Welding, 12 min. Torch Welding, 17 min. How to Braze Aluminum, 7 min.



Riveting

Booklet: Riveting Alcoa Aluminum, 54 pages.

Movie: How to Rivet Aluminum, 26 min.



Casting

Booklet: Casting Alcoa Alloys, 142 pages.

Machining

Booklets: Machining Alcoa Aluminum and Its Alloys, 66 pages. Alcoa Aluminum in Automatic Screw Machines, 96 pages.

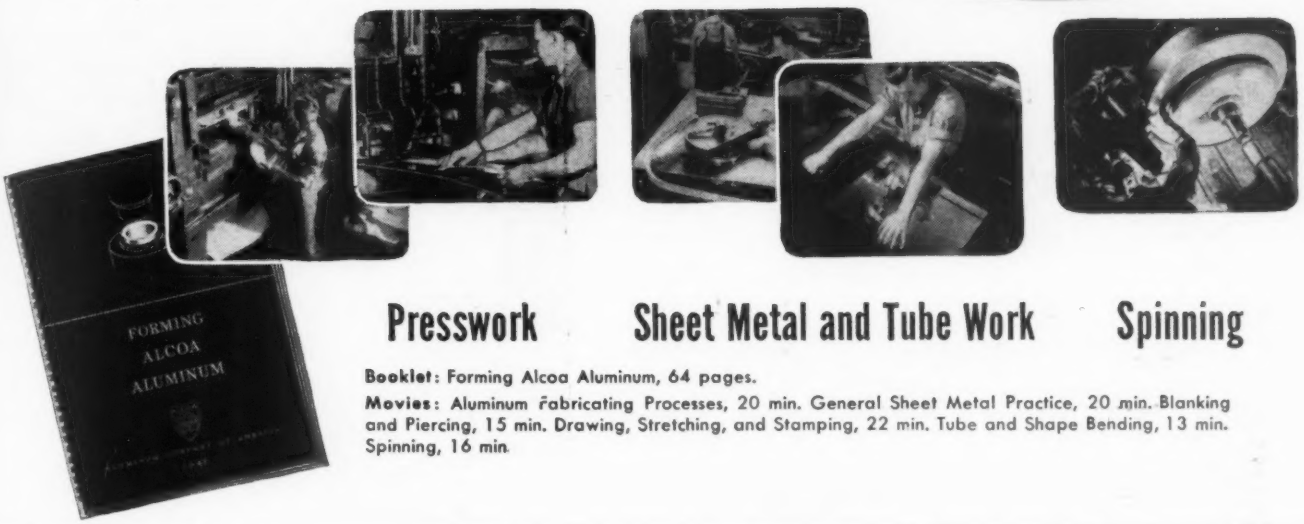
Movie: How to Machine Aluminum, 32 min.

ALCOA®

ALCOA

work with Aluminum

USE ALCOA'S TECHNICAL LIBRARY OF BOOKS AND MOVIES

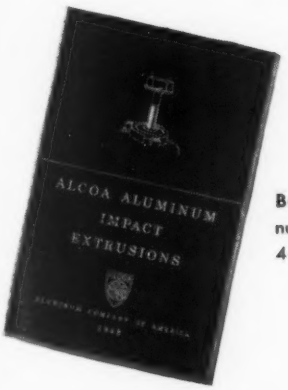


Presswork Sheet Metal and Tube Work Spinning

Booklet: Forming Alcoa Aluminum, 64 pages.

Movies: Aluminum Fabricating Processes, 20 min. General Sheet Metal Practice, 20 min. Blanking and Piercing, 15 min. Drawing, Stretching, and Stamping, 22 min. Tube and Shape Bending, 13 min. Spinning, 16 min.

Impact Extrusions



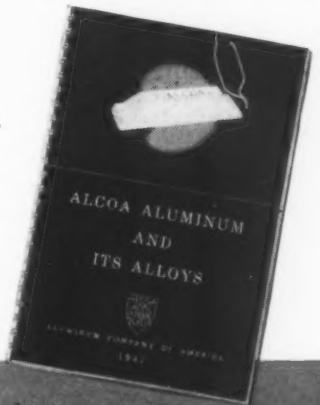
Booklet: Alcoa Aluminum Impact Extrusions, 44 pages.

Finishing

Booklet: Finishes for Alcoa Aluminum, 64 pages.

Alcoa Aluminum and Its Alloys

Contains fundamental fabricating information plus tabular data on the chemical and physical properties of aluminum, 155 pages.



FIRST IN ALUMINUM

WHEN Durez phenolic plastics are described as unsurpassed in versatility, this means the manufacturer of electrical equipment and appliances can count on members of this plastics group to fit *his* special needs.

Even within this one field, Durez offers a wide latitude of characteristics. Easy moldability can be had in a lower power factor material for high-frequency parts. Another retains high dielectric strength at elevated temperatures. Still another has excellent electrical properties closely controlled . . . a type widely used for general purposes. All without sacrifice of impact strength or surface luster!

Whenever you are seeking production speed and economy, along with improved performance or appearance in your product . . . or both . . . consider Durez. With our enlarged plant capacity and perfected quality control, we have much to offer you. "Durez Plastics News", which shows each month what other manufacturers are accomplishing with Durez, is available for the asking.

Durez Plastics & Chemicals, Inc., 1512 Walck Rd., N. Tonawanda, N. Y. *Export Agents: Omni Products Corp., 460 Fourth Avenue New York 16, N. Y.*

NO "SPILLING" through molded Durez when you

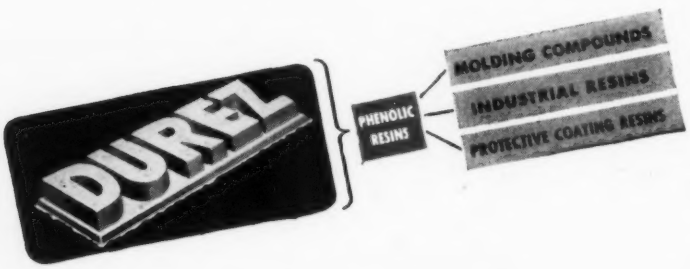
"Pass the Juice"

TRANSFORMER TAP CHANGER. High dielectric strength of the Durez phenolic compound enables these Allis-Chalmers devices to operate at a voltage differential of 15,000 volts at about 50 amps., single phase. Mechanical strength permits heavy spring loading required for positive point contacts. Durez is immune to the hot oil in which tap changer is submerged.

SIGNAL CONTROL UNIT. Normal properties of electrical Durez are all required here . . . dielectric strength, self-insulation, and non-corrosion. Installed along railway lines, these units also possess mechanical stability under wide ranges of atmosphere and temperature.

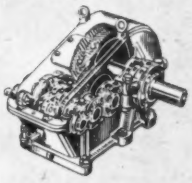
DISTRIBUTOR PARTS. Made with a Durez compound having excellent arc-resistance and a very low shrinkage factor, these parts hold multiple metal inserts and withstand great variations in weather and operating conditions. Durez facilitates production, conforms easily to intricate grooves, holes and bosses in the mold.

HIGH FREQUENCY EQUIPMENT. The Valpey Xtalector permits instant changes from one radio transmission frequency to another. Crystal holders are molded of a Durez compound possessing a high dimensional stability and low electrical loss, assuring maintenance of crystal frequency in extremes of temperature and humidity.

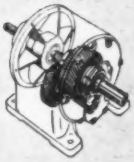


PHENOLIC PLASTICS that fit the job

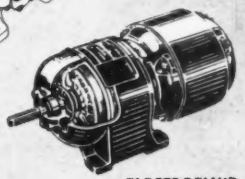
OTHER TYPES OF LINK-BELT POWER TRANSMISSION MACHINERY


HERRINGBONE GEAR SPEED REDUCERS

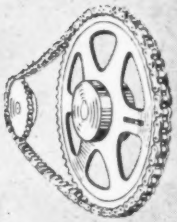
WORM GEAR SPEED REDUCERS

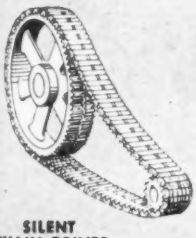

HELICAL GEAR SPEED REDUCERS

GEARMOTORS


ELECTROFLUID DRIVES

P.I.V. GEAR SPEED VARIATORS


SILVERLINK ROLLER CHAIN DRIVES


SILENT CHAIN DRIVES

STEEL AND MALLEABLE CHAIN DRIVES

V-BELT DRIVES

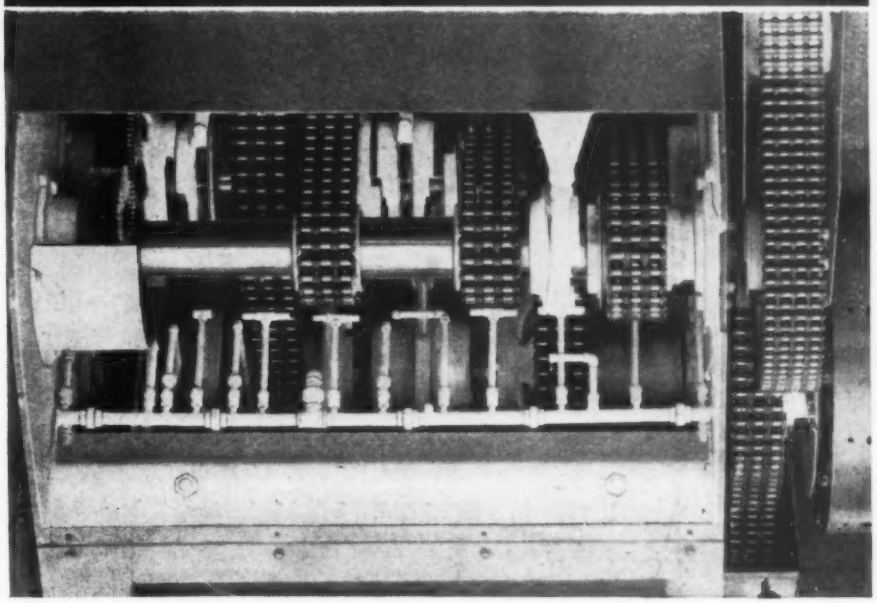
UNMOUNTED BALL AND ROLLER BEARING UNITS

ROLLER BEARING MOUNTED UNITS

BALL BEARING MOUNTED UNITS

BABBITTED BEARINGS

LINK-BELT *Silverlink* ROLLER CHAIN



MEETS THE TEST of SEVEREST SERVICE!

The 6-speed transmission shown above is a good example of the versatility of Link-Belt Silverlink precision-built roller chain and its ability to operate at high speeds under heavy loads.

Silverlink roller chains employed on this unit include 1-½″ pitch quadruple chain drive from engine, and 2″ pitch chains of double, triple and twin double width on the other drives.

To the inherent features of chain, including positive transmission, high efficiency and flexibility, Link-Belt standards of engineering and manufacturing excellence add unsurpassed precision, great strength, light weight, ability to withstand shock, and toughness that assures long life.

Let Link-Belt chain specialists aid you in applying Silverlink roller chain for power transmission or conveying purposes.

Silverlink is furnished in manufacturers' (A.S.A.) standard sizes in single and multiple width, to meet all requirements.

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8.
Offices, Factory Branch Stores and Distributors in Principal Cities.

11.109

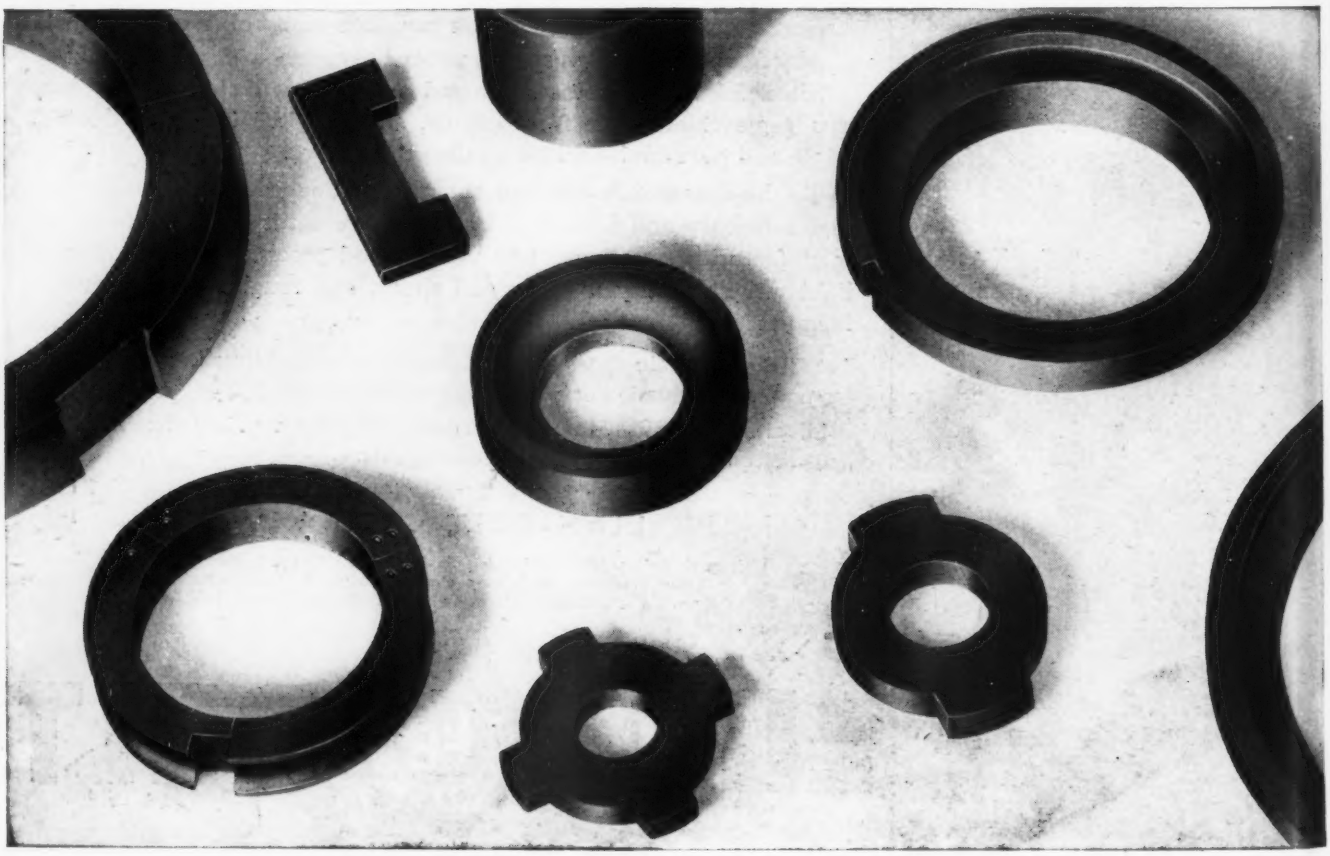
LINK-BELT

Power Transmission Machinery

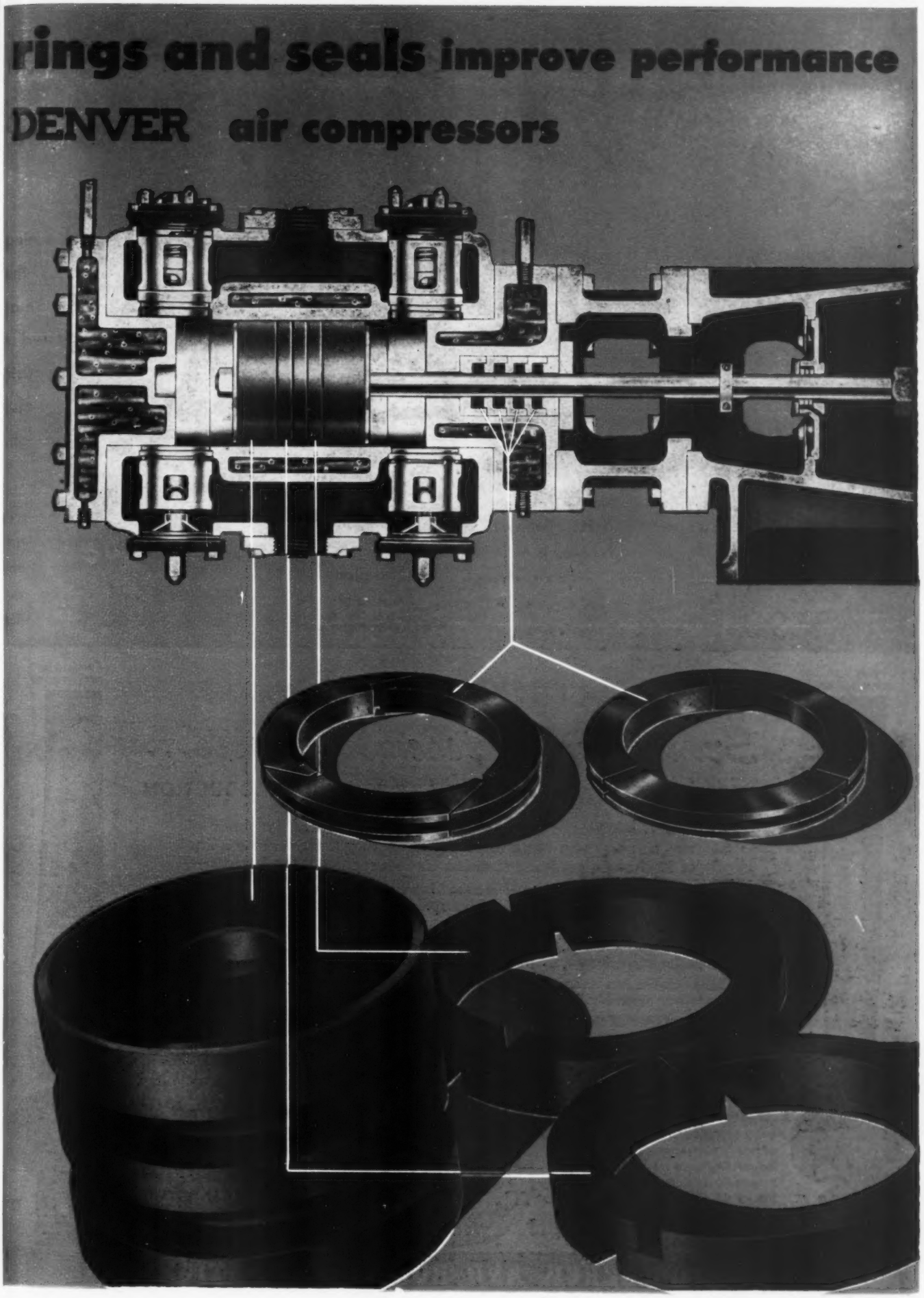
graphitar (Carbon-Graphite) pistons, piston of GARDNER-

The use of Graphitar at vitally important points is one of the reasons for the high operating efficiency and dependability of the Gardner-Denver Company air compressor. Because the piston, piston rings, and piston rod are Graphitar, the compressor needs no lubrication at these points and hence delivers compressed air that is entirely free of oil. Springs seated in grooves machined in the piston expand the Graphitar segmental piston rings to compensate for slight wear, assuring permanent effective sealing. The Graphitar packing rings also are segmented and contract under spring pressure to provide dependable sealing throughout constant use.

GRAPHITAR IS VERSATILE. Self-lubricating, light-weight, highly resistant to wear, temperature extremes and chemical attack, Graphitar is the ideal material for seals, rings, pistons, cylinder liners, and other parts in a wide variety of mechanisms. We are equipped to produce Graphitar parts in any practical size and shape. Tolerances may be as close as .0005" in small sizes. Send us sketches or descriptions of your products and our engineers will show you where Graphitar parts will improve mechanical performance and save you money. Write for 44 page catalog.

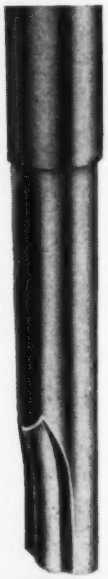


THE UNITED STATES GRAPHITE



COMPANY • SAGINAW, MICHIGAN

TYPE "A" ASSEMBLY BIT



COMMON SCREWDRIVER

Again... CLUTCH HEAD *Screws Scale Down Assembly Costs...*

ELIMINATE SKID DAMAGE AND SMOOTH OUT PRODUCTION

HANSON, a Chicago name nationally recognized as symbolic of weight accuracy, has this to say as to why their complete line of 1949 models is being standardized on CLUTCH HEAD Screws:—

"Compared with the use of other recessed head screws, change-over to CLUTCH HEAD has given us immediate relief from several costly and annoying assembly problems."

"Over and above faster, smoother operation, the non-tapered drive has freed us from the expense and delay arising out of skid damage."

"The Lock-On has definitely simplified for us screw placement in 'awkward' spots in our assembly."

"The durability of the Type 'A' Bit, plus its easy reconditioning, is a time and money saver. Our tool maintenance cost is now almost zero."

"The fact that CLUTCH HEAD operates with a common screwdriver rates high with us as a service factor."

Regardless of the size or type of screw required, these and other exclusive CLUTCH HEAD *advantages will prove their superiority and economy in every phase of assembly production. Their value will be immediately apparent on cursory examination, so we invite you to send for screw assortment, sample Type "A" Bit, and illustrated Brochure . . . to come to you by mail.*

CLUTCH HEAD SCREWS

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

This NEW 1248 Magnetic Counter

is easier to BUILD-IN as an original product-part

Here's another front-page headline from Veeder-Root, in advanced counter-design: A magnetic counter of smaller size . . . with a compact, streamlined, 2-tone case that adapts itself more easily to built-in installations. A magnetic counter that affords the utmost in durability and accuracy because it has fewer working parts. A magnetic counter especially adapted to remote-indication from plant to office.

The New Series 1248 Magnetic Reset Counter features the Veeder-Root "Ease-Eye" Direct-Reading Line of 6 large figures, in large windows, brought out boldly by the contrasting background of a band of light gray . . . *making direct reading easy,* at some distance. What's more, it features higher accuracy, faster operation, and more counts-per-minute. See how readily this new counter will fit into your product's design-limits . . . how it will increase your product's utility and sales. Write.

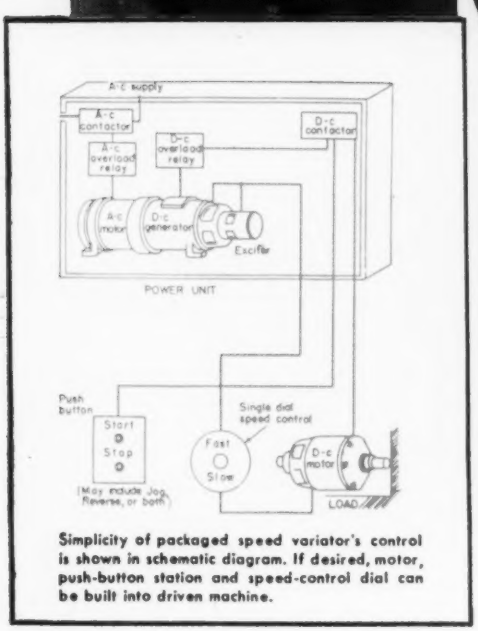
VEEDER-ROOT
INCORPORATED
HARTFORD 2, CONNECTICUT

In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3
In England:
Veeder-Root Ltd., Dickinson Works, 20 Purley Way, Croydon, Surrey

Designer's

ALL WRAPPED UP IN A LOW-COST PACKAGE

THE G-E SPEED VARIATOR!



Simplicity of packaged speed variator's control is shown in schematic diagram. If desired, motor, push-button station and speed-control dial can be built into driven machine.

Now you can incorporate in your designs—at low cost—an adjustable-speed drive that gives the desirable performance of a d-c motor from an a-c power supply. With the G-E packaged Speed Variator, you can obtain smooth, flexible speed control over a 16 to 1 speed range. And because of mass production from standardized parts, you get an engineered system at an economical price, built for your particular application.

Longer life and lower maintenance costs are obtained from the new, compact, air-filtered power-unit case which encloses motor-generator set and control. Factory assembly and unit shipment reduce installation cost. Drive ratings of 3 through 60 hp are available. Ask for Bulletin GEC-280.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON PRODUCTS

FOR MACHINES WITH THE "SHAKES"

From the design standpoint, excessive vibration in moving machinery means trouble. With the G-E recording vibrometer, you can quickly find out the source and degree of vibration and provide for corrective balancing. This lengthens equipment life, saves design and maintenance costs. The vibrometer makes a permanent record of frequency, displacement, and wave-shape in mechanical vibration. It records both steady-state and transient vibrations. Operation is simplicity itself. Just hold the prod extending from the vibrometer against the vibrating body, as illustrated. See Bulletin GEC-310.

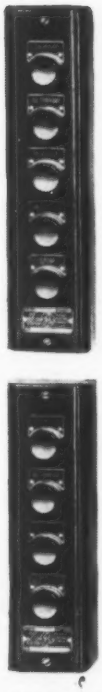
TIME SWITCHES THAT "SAY WHEN"

Here's the lowest-priced high-quality G-E time switch ever—the T-47. A "natural" for low-cost control of motors, heaters, lights, fans, blowers, and similar equipment, it automatically performs one "on" and one "off" operation during any 24-hour period, and repeats daily without further adjustment. It saves electricity, reduces losses due to negligence, and releases operators for other work. Available from stock. See Bulletin GEA-4874.

NEW! HANDY CONTROL BOOKLET

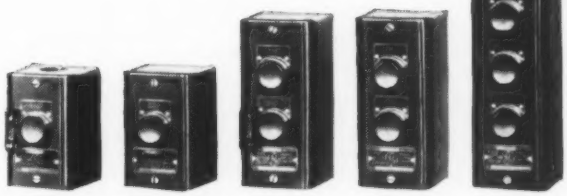
You'll get a quick, helpful review of an important subject for machine designers in "Simplified Guide to A-C Motor Control." Here you'll find pointers on the various functions of control, how to select and apply the commonly used types, when and how to use magnetic and manual control, overload and undervoltage protection, enclosures, etc. See Bulletin GEA-4015.

Off to a Good Start



Add the right touch to your machine designs with one of G.E.'s heavy-duty push-button stations. Designed for use with magnetic controllers, they're made for flush or surface mounting in general-purpose, dust-tight and watertight cases, and in enclosures for use in hazardous areas. Interchangeable units permit many combinations at one station of momentary and maintained contact buttons, selector switches, and indicating lights.

Sturdy, steel enclosures and ample electrical clearances assure operator safety. Large double-break contacts stand up under frequent operation. Installation of the surface-mounted stations shown is simple. Remove the cover and bolt to the desired surface through the mounting holes provided. Easily accessible terminals then make wiring a matter of seconds. See Bulletin GEA-5043.



General Electric Company, Section C668-66
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEC-280—Packaged speed variator
- ☐ GEC-310—Recording vibrometer
- ☐ GEA-4874—T-47 time switch
- ☐ GEA-4015—A-c motor control guide
- ☐ GEA-5043—Push-button stations

YOUR McGRAW-HILL ELECTRICAL CATALOGS show "everything electric" for machinery manufacturers in the G-E section.

Name .....

Company .....

Street .....

City ..... State .....

For your Information

NEWS ABOUT PLASTICS FROM

No shortage of BETTER housings in Monsanto plastics

COUNT THE ADVANTAGES

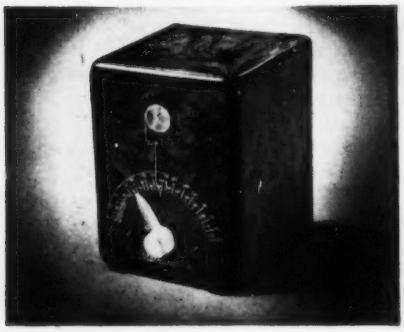
1. **IN FULL SUPPLY.** The plastic you need, when you need it, just as automatically as the tick of the electrically controlled metronome molded in Lustron, Monsanto's polystyrene.

2. **LOW COST.** "ONE-shot" mass production saves finishing, saves costly assembly, takes "human element" losses out of production.

3. **EASILY COMBINED WITH OTHER MATERIALS.** Monsanto plastics can be combined harmoniously with other materials, without production difficulties.

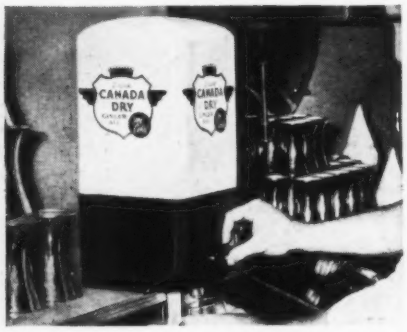
4. **HEAT-RESISTANCE.** The General Electric portable radio cabinet has that extra margin of safety because Lustrex is extra durable, offers highest heat-resistance of any commercially available polystyrene plus all the advantages of regular polystyrene.

5. **SALES APPEAL.** Eye-catching, easily cleaned, rustproof, non-chipping, free of taste or odor . . . Lustron provides a sales plugging counter dispenser for Canada Dry.



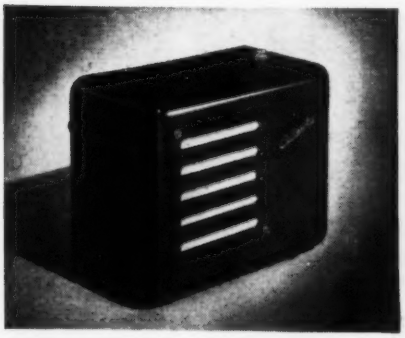
Metronoma by Connecticut Plastic Products, Inc., Waterbury, Ct. for Crystal Research Laboratories, Inc., Hartford, Ct.

Portable radio cabinet molded of Lustrex by General Electric Company, Plastics Division, Pittsfield, Mass.

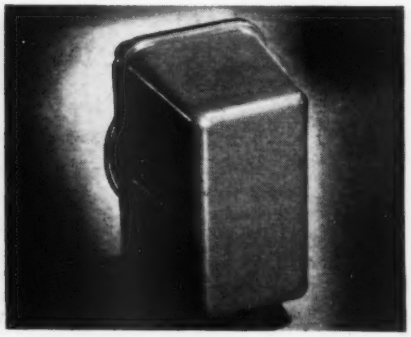


Canada Dry counter dispenser molded of Lustron by General Electric Company, Plastics Division, Pittsfield, Mass.

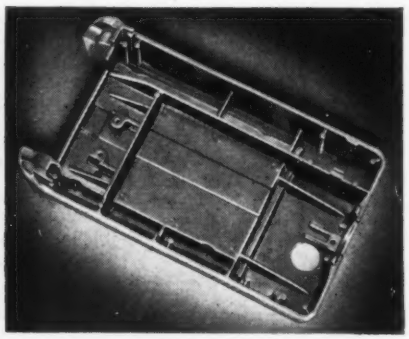
THREE MORE PRACTICAL EXAMPLES of better housing with Monsanto plastics. The Callmaster receiver shows how thermosetting Resinox is easily molded at low cost in intricate designs with metal inserts. NOTE:—Excellent optical properties and non-shattering characteristics of Lustron are ideal to house the translucent red temperature signal light. Sturdy, light weight Resinox features the portable UARCO Sales Register.



Callmaster Intercommunication Set molded of Resinox by REC Manufacturing Corp., Holliston, Mass. for Lyman Electronic Corp., Springfield, Mass.

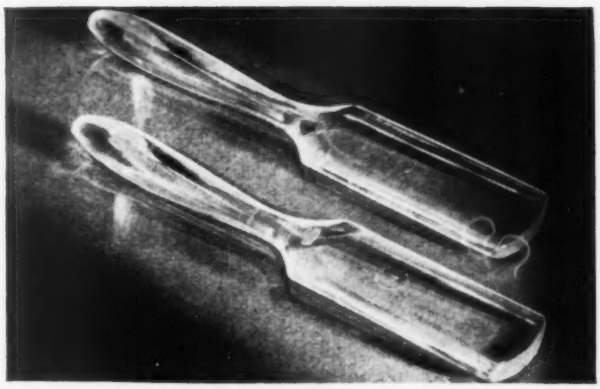


Temperature signal light of Monsanto Lustron molded by Formold Plastics, Inc., Chicago, Illinois, for McCary Manufacturing Co., El Paso, Texas.

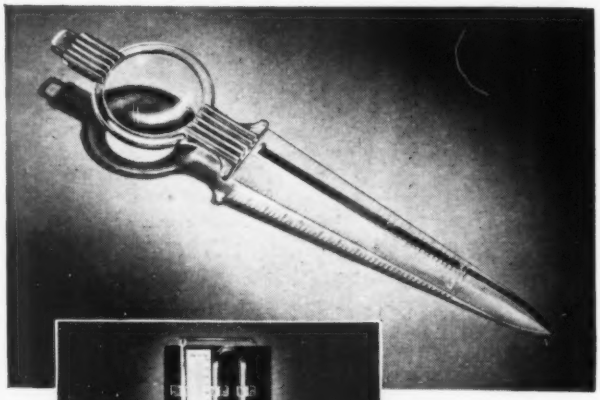


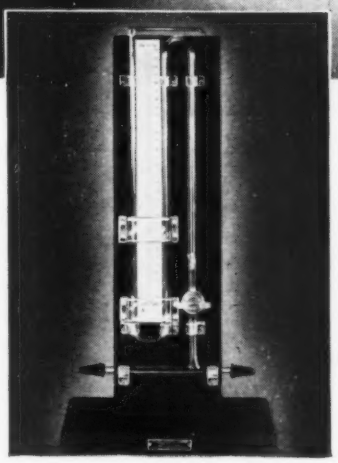
Portable UARCO Autographic Register, body molded of Resinox by Chicago Molded Products Corp., Chicago, Ill., for UARCO Incorporated, Chicago, Ill.

LUSTRON L20-20 means



Brush handles molded of Lustron L2020.





Molded by Connecticut Plastic Products, Waterbury, Conn.

◀ Manometer slides and clips molded by W-L Molding Co., Kalamazoo, Mich., for Fisher Scientific Co., Pittsburgh, Pa.

TWENTY TWENTY CLARITY

Monsanto's Lustron L2020 gives you enduring, water white crystal with definitely superior clarity over other commercially available polystyrene. Actual tests showed these results when L2020 was compared with other leading types of crystal polystyrene.

MATERIAL	YELLOWNESS
Lustron L2020	1.8
Crystal A	2.4
" B	2.5
" C	2.7
" D	2.8
" E	3.0
" F	3.2
" G	3.3
" H	4.8
" I	6.2

Check the clarity of this unexcelled water white crystal when you need exceptionally good transparency that is clear even in thick sections, without cloudiness. Check its excellent optical properties and ability to pipe light. Check L2020, too, for putting extra beauty, utility, and sales into your product.

There are twelve groups of Monsanto plastic materials with thousands of uses. And new uses are constantly being developed. That's why it will pay you to look into Monsanto plastics now . . . to take advantage of ready supply and special technical help.

Lustron, Lustrex, Resinox: Reg. U. S. Pat. Off.

MONSANTO CHEMICALS AND PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY, PLASTICS DIVISION
Dept. PEP12, Springfield 2, Mass.

Please send me information on ☐ *Lustron,* ☐ *Lustrex,* ☐ *Resinox.*
An enclosed letter describes the use I have in mind for plastics.

Name _____ Title _____

Company _____

Address _____

City _____ State _____

Said the careful shopper—
"I want the plastic that will stand boiling water"

It happened in one of the big Pittsburgh department stores. A customer walked up to a table of plastic kitchen ware. The clerk showed her some colorful plastic items . . . but she wouldn't buy. Finally the customer said, "I've heard of a new plastic that will stand boiling water. That's the kind I want."

The clerk was stumped. She didn't know for sure if any of them would stand water that hot.

At this point, a Koppers representative who had overheard the conversation, stepped up.

"Pardon me, ladies," he said, "but I know the plastic you want. It's the new heat-resisting plastic, made by Koppers—Polystyrene P-8." He told the customer how the new plastic stood the test of boiling water for 30 minutes and how it could be safely washed in the automatic home dishwasher . . . and finally that it cost no more than other thermoplastics.

Both the customer and sales clerk were intrigued. Both wanted to know when the new plastic would be available. The answer to that question is . . . *NOW!* Molders can order Koppers Polystyrene P-8 today . . . and the quicker you place your order, the quicker you'll be able to produce the new plastic items your customers have been waiting for.

Here it is— Koppers new heat-resisting POLYSTYRENE P-8

The case of the customer who insists on *heat resisting* plastics is being duplicated in hundreds of stores throughout the country. If your product is one that must be washed or used in hot water, if it must stand the concentrated heat of a radio tube, Koppers New Polystyrene P-8 is the plastic for you.

In repeated tests, products made of P-8 have withstood boiling water continuously for a half hour period—much longer and at higher temperatures than is usual for dishwashing. And in the standard A.S.T.M. heat distortion test, P-8 shows heat resistance 10° higher than the best regularly priced polystyrene previously obtainable.

Costs no more. Koppers Polystyrene P-8 sells at the same price as regular polystyrene. There's no premium to pay—no reason for not switching to this low-cost superior material.

Has better moldability and extrudability. Koppers P-8 has an extremely fast molding cycle. You get more pieces per hour and a higher percentage of perfect pieces. P-8 is a product of reliable uniformity with the same qualities maintained in each shipment. There is less scrap and what scrap there is can be ground up and used again.

Comes crystal clear or in a rainbow of colors. All of Koppers Polystyrenes are first made crystal clear. Each has unlimited color possibilities. Our skillful color-matching technicians can duplicate any color you want in transparents, translucents and opaques . . . pale pastels or brilliant hues . . . snow-white or jet-black. And they can duplicate your color, order after order.

Made by a new and different commercial process. This enables Koppers to offer you a complete line of Polystyrenes—all at the same low cost—all quality controlled in every step of manufacture. Send the coupon for information on all of Koppers Plastics.

KOPPERS COMPANY, INC.
Chemical Division, Pittsburgh 19, Pa.

Free
BOOKLET ON KOPPERS PLASTICS

Koppers Company, Inc.
Chemical Division, PE12
Pittsburgh 19, Pa.

Please send me your new booklet on Koppers Plastics.

Name_____

Company_____

Position_____

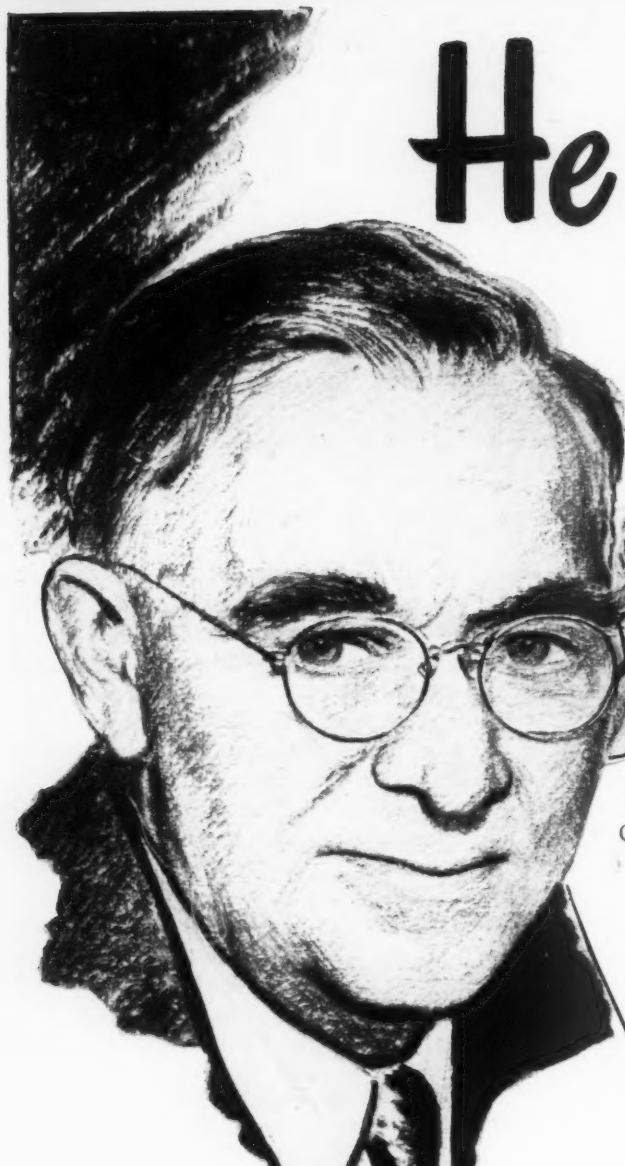
Address_____

KOPPERS

Koppers Plastics

•POLYSTYRENE •CELLULOSE ACETATE •ETHYL CELLULOSE

He simplifies d
He uses S



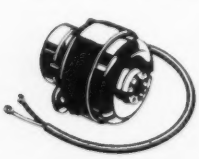
Clean, compact design is one of the most attractive features of Albertson portable tools. For this, small-motor standardization gets more than a small share of the credit. Here's the way Mr. G. A. Olsen, chief engineer of the Albertson Co. feels about it. "I simplify design," he says, "when I specify series-motor parts with NEMA standard dimensions. By designing tool housings to take parts conforming to these standards, I simplify case construction, obtain interchangeable motor design and lower overall engineering costs."

More for your money with STANDARD Fractional-Horsepower MOTORS

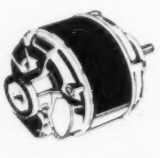
GENERAL ELECTRIC is now producing *definite-purpose* motors, such as washing-machine motors, sump-pump motors, hermetics and the others shown below, as well as 11 types of general-purpose motors. These are being made in *standard designs*. Ratings, performance standards, dimensions, and special features (such as type of enclosure, bearings, etc.) follow the standards worked out by the National Electrical Manufacturers Association in conjunction with your industry associations. Thus, you get all the advantages of standardization and—over 1600 G-E standard motors to choose from.

A Recent Bulletin You'll Want. A brief, but concise G-E bulletin tells what the standards are and how they are applied. Ask your local G-E office for Bulletin GES-3565 or write *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Lower Prices are Proof. Increased production costs made it necessary for General Electric to adjust its prices upwards in June of 1948. However, prices on fractional horsepower motors are still 5% lower than they were in December, 1947 due to two successive price reductions in 1948 both of which were direct results of the standardization program. With fewer motor types to build, G.E. has been able to concentrate on those motors most widely demanded. The resulting savings are passed along to you and your customers as worthwhile price reductions.



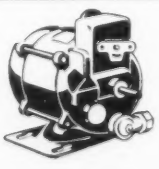
Unit-Bearing Fan



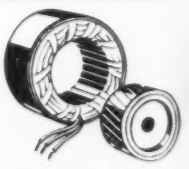
Washing Machine

Oil Burner

Machine Tool



Gas Pump

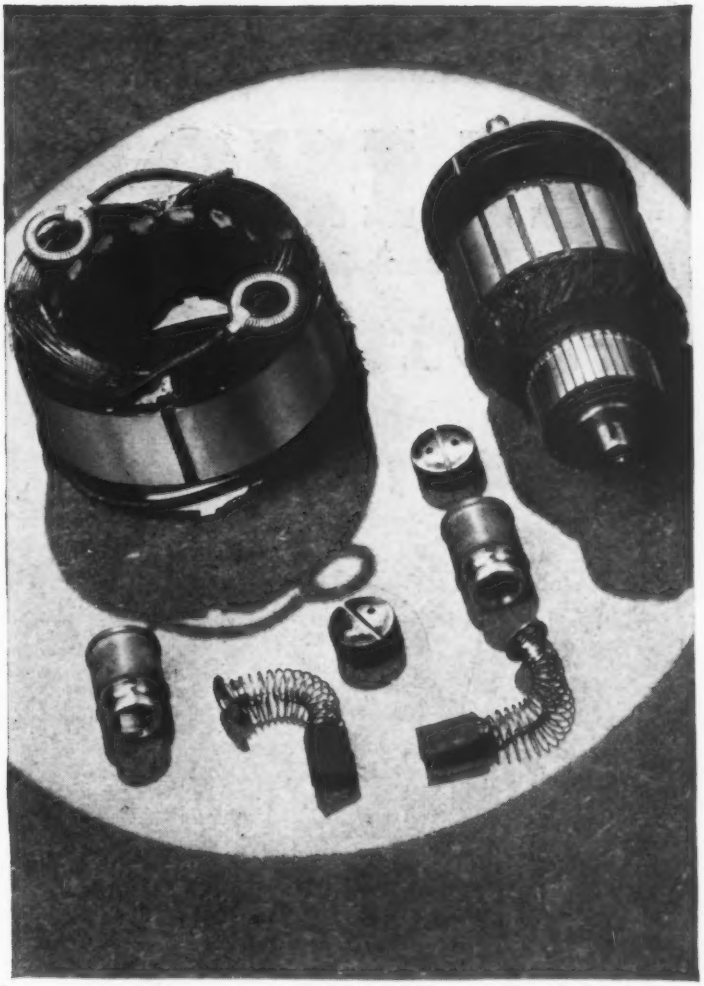


Hermetic Refrigeration

design

STANDARD

SERIES MOTOR PARTS



General Electric offers all manufacturers of portable tools, business machines, and small appliances a complete line of fractional horsepower series motor parts tailored individually to meet a wide variety of requirements. These series motor parts are composed of standardized components—brushes, commutators and laminations, with shafts dimensions and performance modified to meet special needs. With these standardized components, device manufacturers save on engineering time and motor costs.

These motors are classified in two principal groups:

Heavy Duty Parts—A complete line to stand up under rugged service, featuring high efficiency and good speed regulation. Primarily for portable tools such as drills, saws, and sanders, they have extra features to withstand heavy short-duration overloads and high light load speeds.

Normal Duty Parts—In smaller sizes and for more uniform loads than the heavy duty parts. Made especially for such devices as vacuum cleaners, blowers, mixers, and small floor polishers, where good performance and reliability are essential, but where not all the extra features in heavy duty parts are needed.

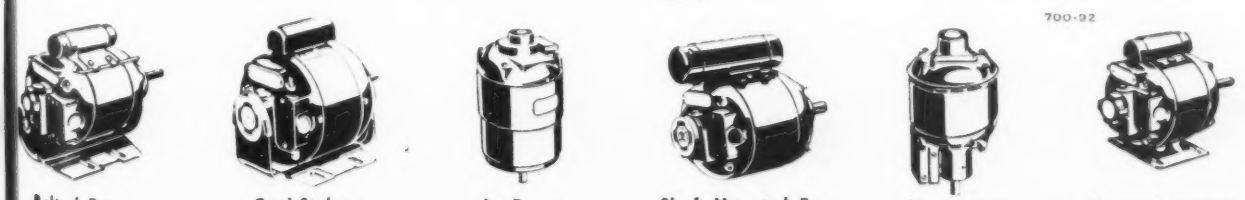
Important Construction Features of G-E Series Motor Parts

Commutator—Precision built, strong, and accurately finished to operate quietly and have long life. **Commutator Leads**—Firmly staked in commutator bars, soldered, and secured for maximum protection against breakage. **Armature**—Carefully wound and insulated to meet specifications. Balanced for smooth operation, fan cooled for long life. **Field Assembly**—Standardized dimensions closely maintained for easy assembly in customer's device. Insulated windings anchored in the lamination assembly have flexible leads to facilitate connections. **Brush Assemblies**—Made from scientifically selected materials which assure long service, protect commutator surfaces, and give excellent commutation.

For further information on G.E., series motor parts, write for Bulletin GEA 1942. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

GENERAL ELECTRIC

700-92



Belted Fan | Coal Stoker | Jet Pump | Shaft-Mounted Fan | Sump Pump | General Purpose

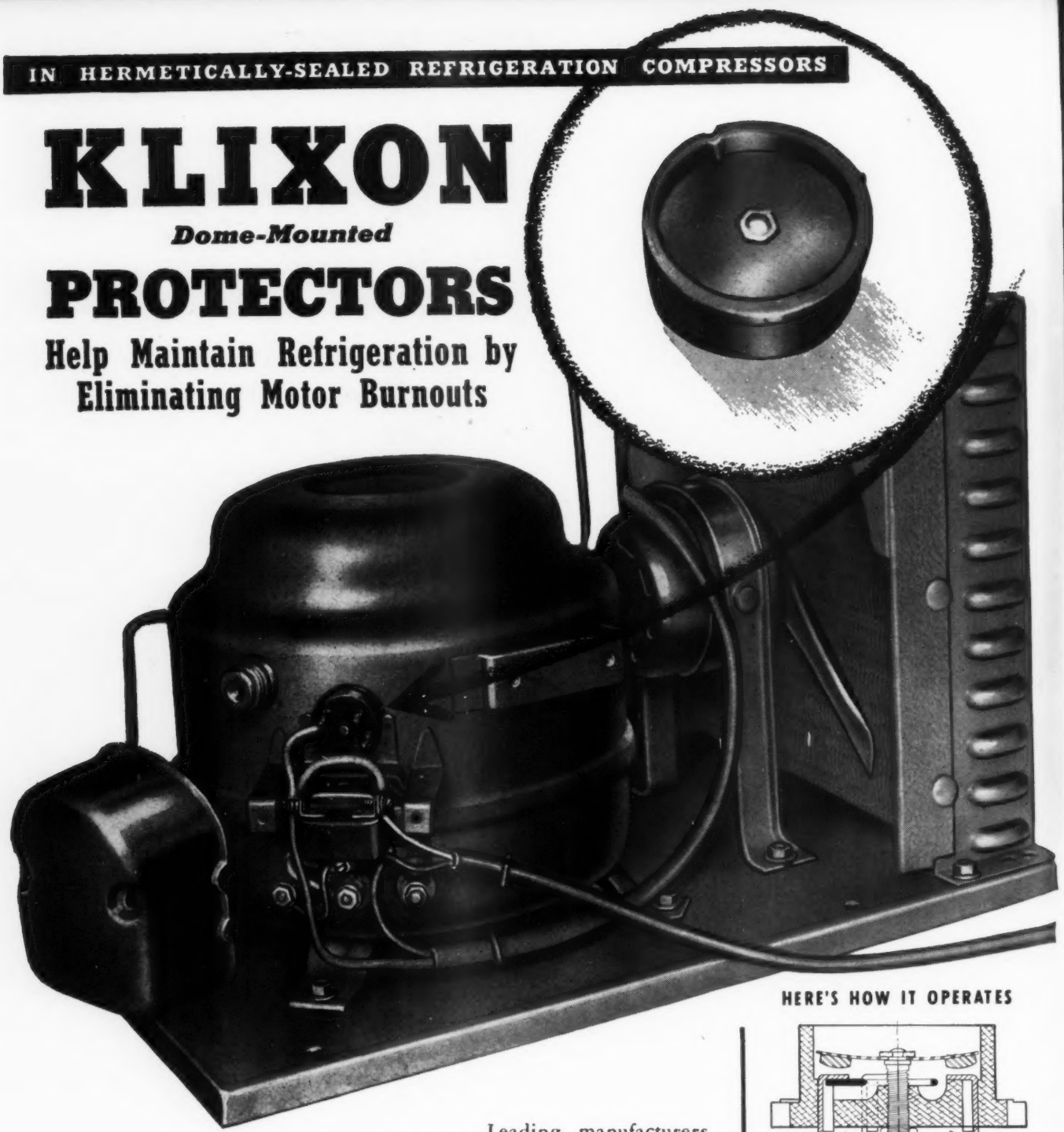
IN HERMETICALLY-SEALED REFRIGERATION COMPRESSORS

KLIXON

Dome-Mounted

PROTECTORS

Help Maintain Refrigeration by Eliminating Motor Burnouts



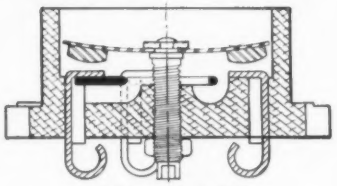
Leading manufacturers of hermetically-sealed refrigeration compressors and users of these units who incorporate them into their equipment use and specify Klixon Dome-Mounted Protectors to prevent motor burnouts and assure long motor life.

The Klixon Protector takes into account the motor destroying factors and shuts off the power should the motor become dangerously overheated. When it cools sufficiently, it turns on the power again enabling the hermetic unit to continue refrigeration.

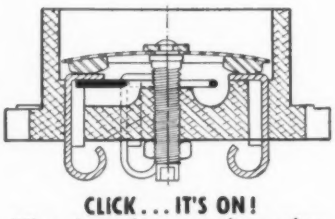
Regardless of the motor driven products that you manufacture, it will pay you to use motors that have built-in Klixon Protectors. Also specify Klixon Protectors on the transformers, solenoids, variable voltage transformers that you buy.
Klixon Protectors prevent burnouts, cut repairs and replacements.

KLIXON
TRADE MARK REG. U. S. PAT. OFF.

HERE'S HOW IT OPERATES



CLICK . . . IT'S OFF!
When temperature within the equipment reaches danger point, KLIXON Protector snaps the power "OFF" preventing burnouts.



CLICK . . . IT'S ON!
When the equipment cools to safety, the Klixon Protector snaps the power "on" automatically if the automatic reset is specified . . . or when the reset button is pushed when manual type is specified.

SPENCER THERMOSTAT COMPANY, 912 FOREST ST., ATTLEBORO, MASS.

Through these portals pass chemicals most challenging to metals!

Alkalies from soaps. Acids from medicines. Oils from cosmetics. Alcohols from hair tonics. Solvents from cleaners. Discoloring agents.

Add to these enemies of metal furniture—abrasion from razors, scissors, equipment. Wear from daily use. Impact from careless removal and replacement of innocent-looking articles!

If anything ever called louder for a metal coating based on VINYLITE Brand Plastics, it would be hard to find. Yet there are hundreds of other items, for indoor use and out, whose life-expectancy could be greatly increased by wonder-working VINYLITE Plastic finishes—kitchen, garden, bathroom, hospital, office furniture of many kinds.

For metal coatings based on VINYLITE Resins are chemical-resistant, abrasion-resistant, and tough. Inherently elastic, they never check, flake or become brittle. They are cleaned with just a damp cloth, although strong cleaners do not hurt them. They are odorless, and do not pick up odors.

VINYLITE Resins are moderate in cost, easy to apply, and often effect production savings. They are available in all colors. If you make furniture—from stools to step-ladders—for home, industry or institutions, write to Department **DR-10** for information on formulations, costs, service records and suppliers. The expert counsel of Bakelite Corporation engineers is at your service.

VINYLITE

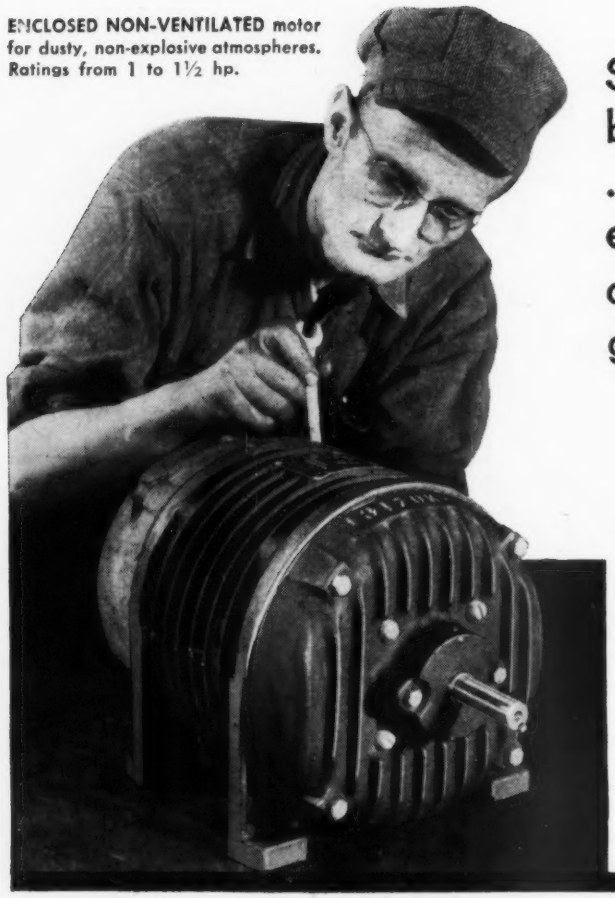
TRADE-MARK

PLASTICS

BAKELITE CORPORATION, *Unit of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N.Y.

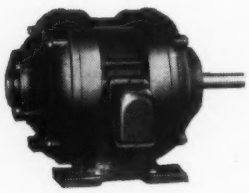
ALLIS-CHALMERS OFFERS EQUIPMENT

Looking for

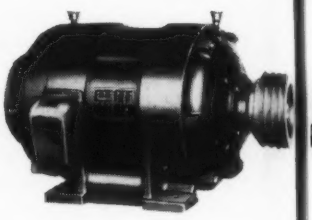


ENCLOSED NON-VENTILATED motor for dusty, non-explosive atmospheres. Ratings from 1 to 1½ hp.

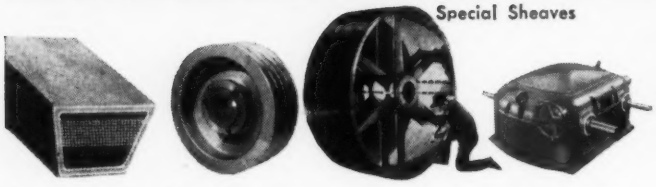
Specify Allis-Chalmers . . . for quality backed by 50 years of motor building . . . a century of manufacturing experience. Motors from ½ HP to any size . . . and a nation-wide certified service program to *keep* your motors running!



GENERAL PURPOSE motor handles 90% of all alternating current motor requirements. Ruggedly constructed with distortionless rotor. Sizes from 1½ to 200 hp.

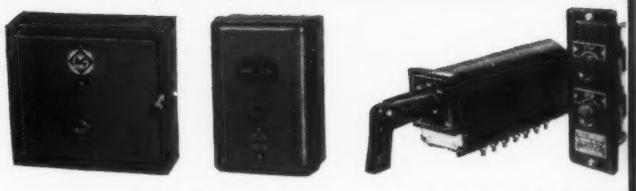


ENCLOSED FAN-COOLED motor for use in dusty atmospheres where danger of explosion does not exist. Suitable for outdoor use. Sizes from ½ to 200 hp.



Special Sheaves

Super-7 V-Belts *Magic-Grip* Sheaves Speed Changers



Motor Starters Rotary Control and Push Buttons

Texrope V-Belt Drives

Fastest delivery in industry on standard V-Belt sizes and lengths. Constant speed drives include complete line of *Texiron, Texsteel, Texdrive, Magic-Grip,* standard cast iron and steel sheaves for section A, B, C, D, and E belts. For adjustable speed, Vari-Pitch sheaves give speed range of 100% per sheave, *Vari-Pitch* speed changers 375% range.

Controls — Any Type or Size

Across-the-line starters for a-c motors range from size 0 to 7. Manual or magnetic, full or reduced voltage starters for any industrial application. Standard, dust-tight, water-tight, and explosion-proof enclosures. Standard and heavy duty push button stations, rotary switches, voltage regulators, contactors and relays.

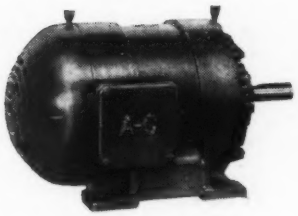
Sold — Applied — Serviced by Authorized Dealers, Certified Service Shops, and District Offices Throughout U. S.

ALLIS

AID TO MACHINE DESIGNERS!

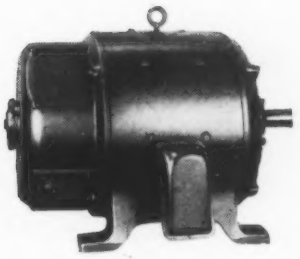
Quality Motors?

VERTICAL MOTOR TYPE ARV. Available in open, enclosed, fan-cooled, splash-proof, and explosion-proof types. Ratings from 1½ to 200 hp, 25, 50, and 60 cycles.

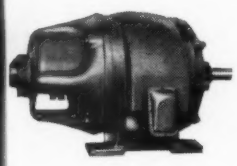


EXPLOSION-PROOF approved by Underwriters for Class I, Group D, and Class II, Group G locations. Safe in atmospheres containing gasoline, etc. ¾ to 200 hp.

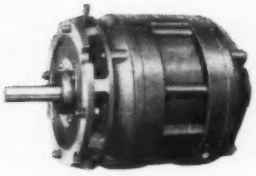
SPLASH-PROOF excludes top or side directed particles or liquids. Squirrel cage type with anti-friction bearings. Available in ratings from 1½ to 200 hp.



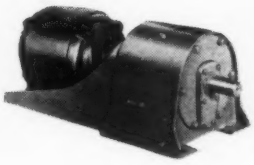
DIRECT CURRENT motors for adjustable speed and continuous reversing drives. Furnished in open, drip-proof, splash-proof and other modifications. ½ to 200 hp.



WOUND ROTOR motor for use where high starting torque and low starting current is required . . . also for adjustable speed drives. Open, splash-proof and enclosed. ½ to 200 hp.

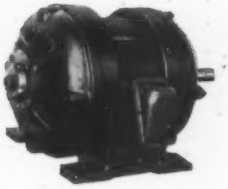


SIDE OR ANGLE mounting motor in open, enclosed fan-cooled, splash-proof and explosion-proof types. Ratings from 1½ to 75 hp. Normal or high starting torque windings.



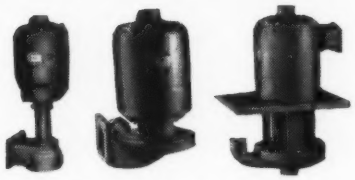
GEARMOTORS for low-speed drives give speeds from 7.5 rpm to 780 rpm using 1750 rpm motor. Class I, II, and III gears. All motor and Integral types. 1 to 75 hp.

GENERAL PURPOSE in ratings from 1 to 7½ hp. Here's a small, tough, squirrel-cage motor with anti-friction bearings. Normal or high starting torque, normal or low starting current.



MULTI-SPEED SQUIRREL CAGE motors in constant torque, variable torque, and constant horsepower types. Two or four speeds. Sizes range from ⅛ to 75 hp. Speeds 450 to 3600 rpm.

Electrifugal Pump.



Coolant and Circulating Pump.

Pumps — 10 to 10,000 gpm

Electrifugal pumps have bracket and flange cast integral with motor frame. This insures perfect alignment of pump and motor. Use for general purpose pumping from 15 to 1600 gpm — heads to 180 ft. — motors from ¾ to 25 hp. Complete line of coolant and circulating pumps are now available for quick delivery.

Electrifugal, Texrope, Super-7, Texiron, Texsteel, Texdrive, Magic-Grip and *Vari-Pitch* are Allis-Chalmers trademarks.

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Please send me:

- ☐ Handy Guide to Electric Motors (51B6052H
- ☐ Handy Guide to Centrifugal Pumps (53B6059D)
- ☐ Handy Guide to Texrope Drives (20B6051H)
- ☐ Variable Voltage Planer Drives
- ☐ Equipment for Machine Tools (25B7110)
- ☐ D-C Remote Indications and Controls (14B6641)
- ☐ Coolant Circulating Pumps (52B6975)
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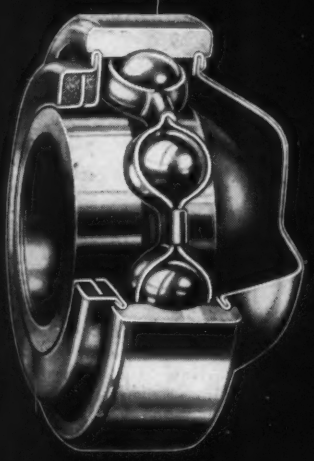
ALLIS-CHALMERS

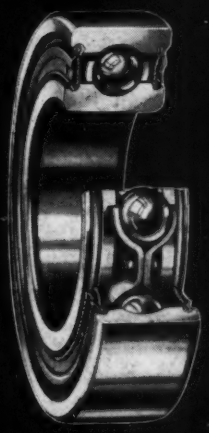
Sealed-for-life Ball Bearings

originated, developed and—

Built to be forgotten by NEW DEPARTURE



Conveyor Roll Bearing, sealed for life, ends expensive greasing of conveyor systems.



Sealed-for-life General Purpose Ball Bearing interchangeable with standard non-sealed bearings. For more facts, ask for booklet, "Sealed."

nothing rolls like a ball...

NEW DEPARTURE

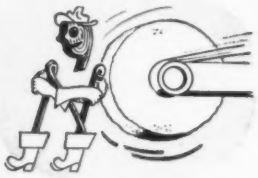
BALL BEARINGS

NEW DEPARTURE · Division of GENERAL MOTORS · BRISTOL, CONNECTICUT

HERE'S WHY NEOPRENE PRODUCTS DO SO MANY JOBS SO WELL

They resist
SUNLIGHT AND WEATHERING—in a class by themselves in resistance to rubber's worst enemies.

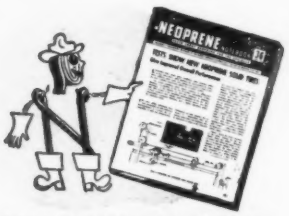
They resist
OILS, SOLVENTS, MOST CHEMICALS—set the standard for oil resistance throughout industry.



They resist
ABRASION, CUTTING, CHIPPING—are tough and durable under severe service conditions.

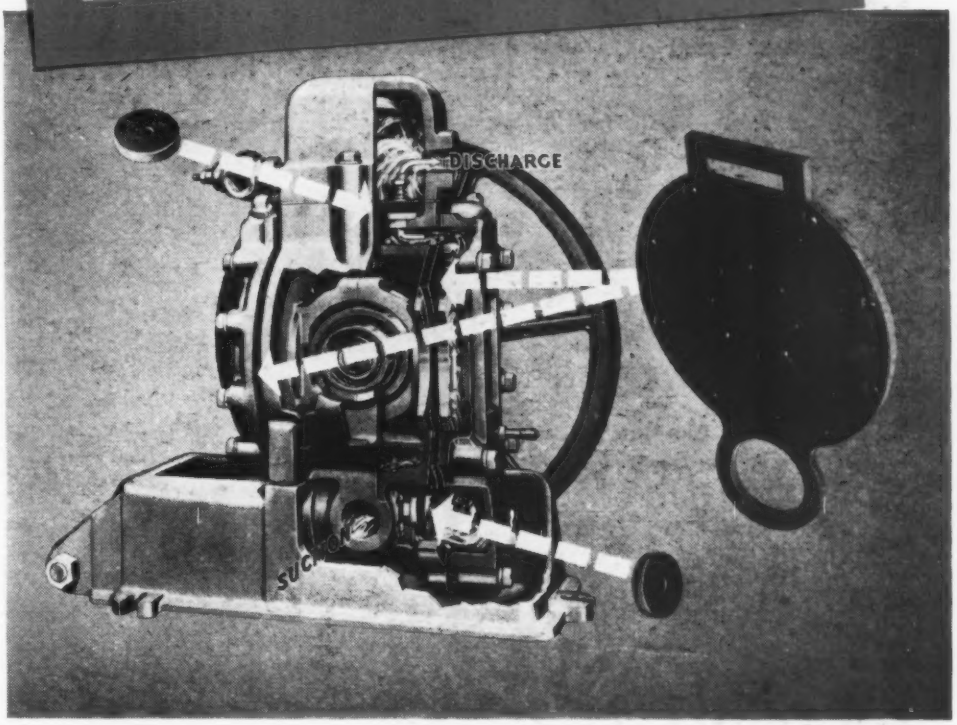
They resist
AIR AND GAS DIFFUSION—have low permeability to gases—retain air longer.

They resist
LOW TEMPERATURE STIFFENING—special compounds retain flexibility at sub-zero exposure over long periods.



FREE! THE NEOPRENE NOTEBOOK—Interesting stories...new, unusual applications of neoprene. Write E. I. du Pont de Nemours & Co. (Inc.), Rubber Chemicals Division **B12**, Wilmington 98, Delaware.

Better rubber products are made with Du Pont NEOPRENE



Courtesy Ace Pump Corporation, Memphis, Tennessee

for example:

Manufacturer puts two-year guarantee on NEOPRENE parts in patented pump

This pump is designed so that packing glands are eliminated, no lubrication is required, and reasonable amounts of abrasive materials may be pumped without damage to any of the parts.

Here's what the manufacturer says about the neoprene diaphragms and valves used in the pump:

"We have operated these pumps on our test well continuously for a period of time equivalent to seven years of normal pump service, and the diaphragm and valves do not show any appreciable wear at the end of these tests.

"We put a two-year guarantee on the diaphragms and valves, and we have *never been called upon for replacement of one of these parts under the warranty, nor do we know of a single failure in the field.*"

The properties of neoprene play an important part in the success of this pump design, contributing to its long service life and successful operation.

Perhaps neoprene can help *you*, too. If you have a problem involving rubber, check the many excellent properties of Du Pont neoprene. We'll be glad to furnish you technical information. And we'll work with your supplier to find an adequate source of supply. Rubber Chemicals Division B-12, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

Tune in to Du Pont "CAVALCADE OF AMERICA," *Monday nights—NBC coast to coast.*

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BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

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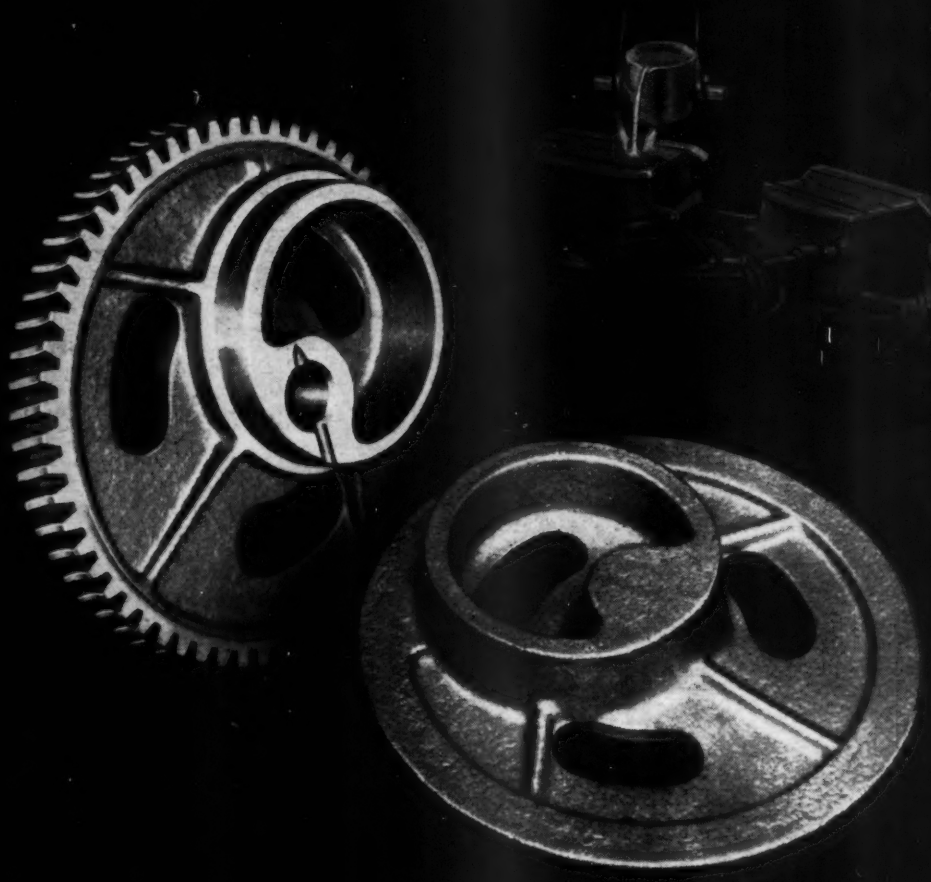

EATON
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FOUNDRY DIVISION
9771 French Road • Detroit 13, Michigan

For those critical applications where a dense, non-porous structure is an essential characteristic, Eaton Permanent Mold Gray Iron Castings offer worthwhile advantages. High tensile strength, freedom from leakage under pressure, freedom from distortion, and ability to take a high, mirror-like finish recommend Eaton Permanent Mold Castings, particularly for refrigeration and hydraulic applications. Free machinability makes for maximum production speed with a high percentage of perfect parts.

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Yes . . . Electro Dynamic, famed maker of electric power plants for the Navy and Merchant Marine, is now producing a complete line of *industrial* motors.

For 69 years Electro Dynamic has built great motors. Thoroughly experienced engineering and the highest degree of manufacturing craftsmanship have earned for E.D. products a solid reputation for great stamina and complete dependability. These invaluable qualities are incorporated in the new Electro Dynamic *industrial motors.*

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Custom Craftsmanship at Competitive Prices

Every Electro Dynamic motor is manufactured with the closest attention to detail, by craftsmen of long experience, to achieve famous E.D. stamina and dependability. Yet, with all their custom craftsmanship, these fine motors are priced on a strictly competitive basis.

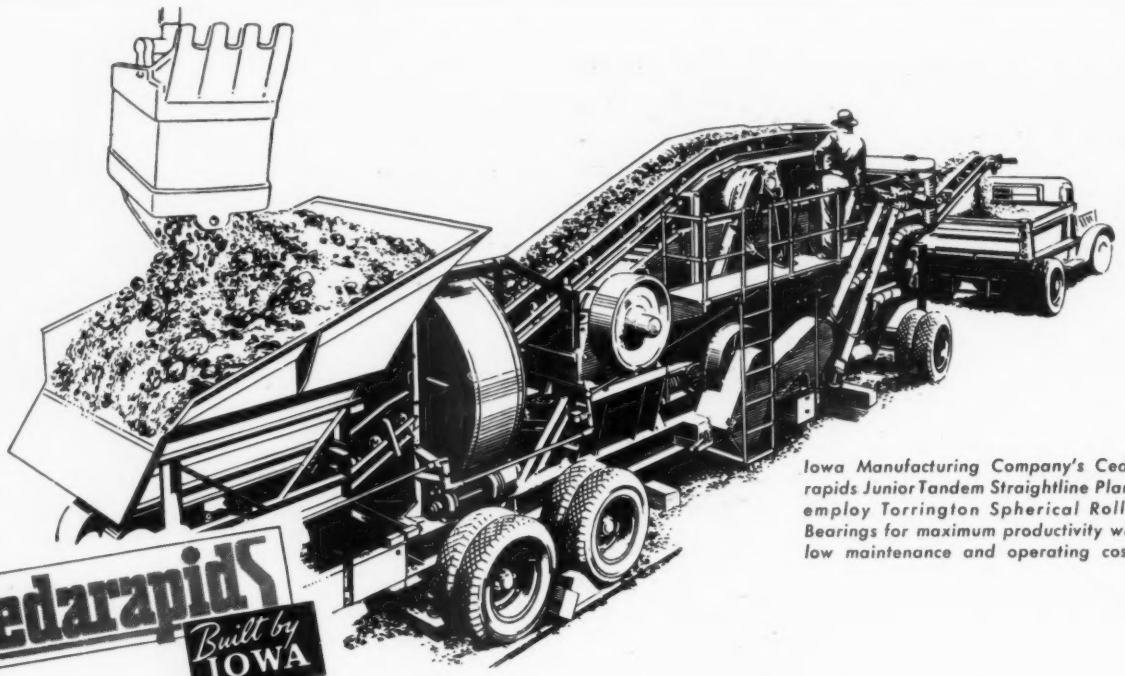
Electro Dynamic is geared to give your order personalized attention. You deal direct with "headquarters", with men who are close to the manufacturing operation.

Our engineers cooperate closely with yours to provide an E.D. power plant exactly suited to your needs.

Industry is learning what marine engineers have known since 1880

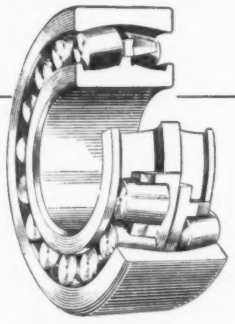
ELECTRO DYNAMIC makes great motors

ELECTRO DYNAMIC • Division of the Electric Boat Company • Bayonne, N. J.



Iowa Manufacturing Company's Cedarapids Junior Tandem Straightline Plants employ Torrington Spherical Roller Bearings for maximum productivity with low maintenance and operating costs.

for High Production and Reliability with TORRINGTON Spherical Roller Bearings



...long service life another advantage of the use of these efficient anti-friction bearings in heavy-duty equipment.

The "CEDARAPIDS" Junior Tandem Straightline Plant employs a jaw crusher, roll crusher and a vibrating screen for the proper sizing and grading of aggregates for construction purposes. To meet exacting specifications for aggregate, hour after hour, day after day, crushing and screening equipment has to take a lot of punishment. That's why IOWA uses TORRINGTON Spherical Roller Bearings on the main and eccentric shafts of the jaw crushers and vibrating screens.

Many leading manufacturers of heavy-duty equipment for the construction and other fields —steel, oil, paper and machine tool—use Torrington Spherical Roller Bearings to advantage. Low friction coefficient, precision construction, self-alignment under deflection, high radial and two-directional thrust capacity are features that combine in providing better performance and lower maintenance and operating costs.

Torrington's engineers have had years of specialized experience in the design, manufacture and application of all major types of anti-friction bearings. You can profit from their assistance on any bearing problem. Call or write the nearest Torrington office.

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South Bend 21, Ind. • Torrington, Conn.
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SPHERICAL ROLLER · TAPERED ROLLER · STRAIGHT ROLLER · NEEDLE · BALL · NEEDLE ROLLERS

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largest hydroelectric development in the world . . . employs WESTINGHOUSE INSTRUMENTS

The *Coordinated Design and Styling* of Westinghouse instruments contribute greatly to the space-saving arrangement and excellent appearance of this installation.

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What are YOUR electrical measuring problems?

Would they include—reliable performance . . . styling . . . size . . . readability . . . or different types of service . . . portable . . . switchboard . . . panel . . . recording?

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Westinghouse Instruments Also Provide You With

- Dials that *stay* white under all conditions.
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- Quick delivery of more different ratings and types.
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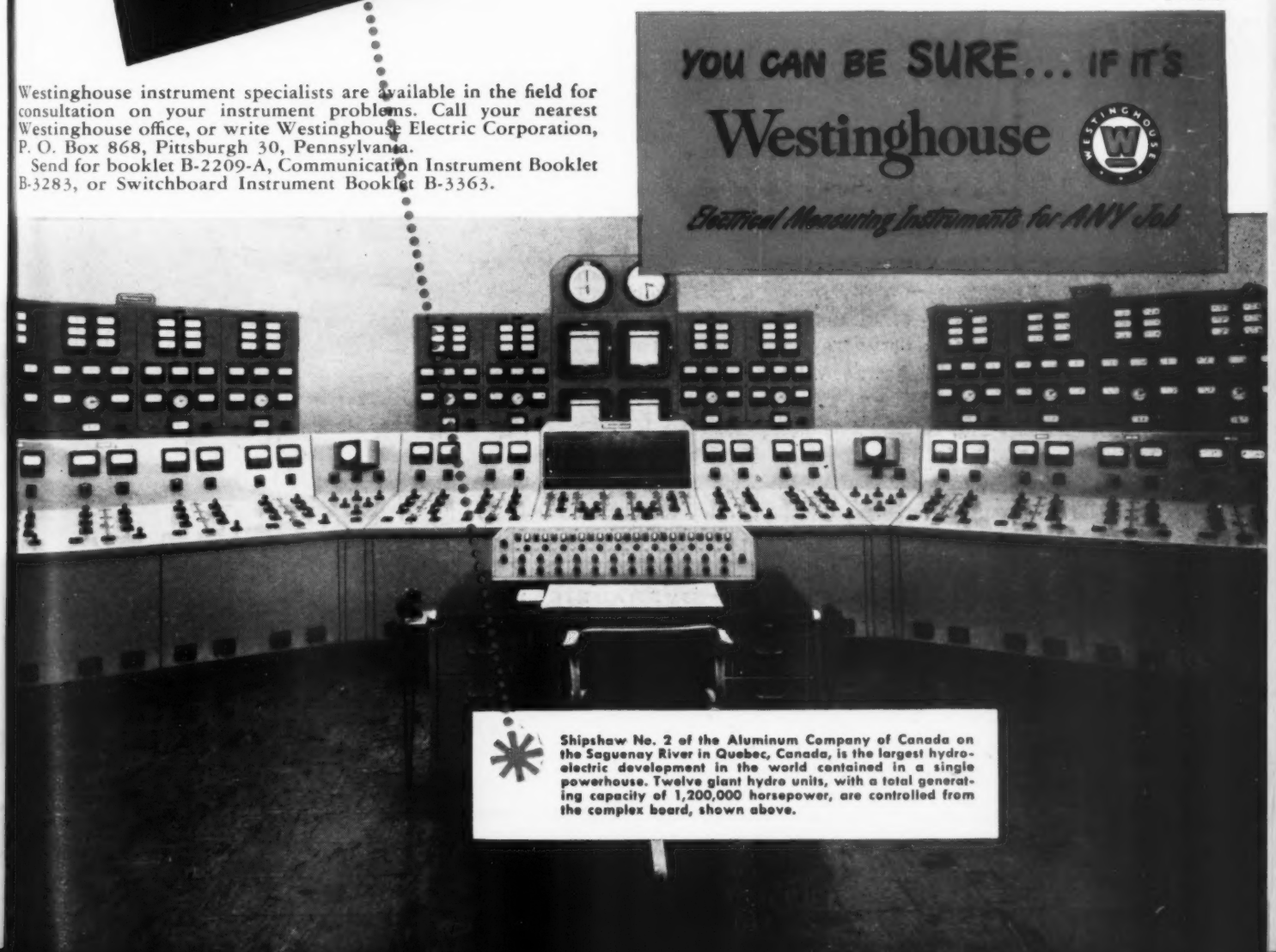
J-40363

Westinghouse instrument specialists are available in the field for consultation on your instrument problems. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

Send for booklet B-2209-A, Communication Instrument Booklet B-3283, or Switchboard Instrument Booklet B-3363.



Shipshaw No. 2 of the Aluminum Company of Canada on the Saguenay River in Quebec, Canada, is the largest hydro-electric development in the world contained in a single powerhouse. Twelve giant hydro units, with a total generating capacity of 1,200,000 horsepower, are controlled from the complex board, shown above.

Are you looking for a better way to control temperature or pressure, seal shafts or valves against leakage, or transmit motion? If you are, it may pay you to look further into bellows assemblies. An easy, low-cost way to do it is to let our engineering department do the looking for you. That's what the users of the bellows assemblies shown above did, and they're happy about it. Why not send *your* sketches and specifications to us for confidential analysis and recommendations?

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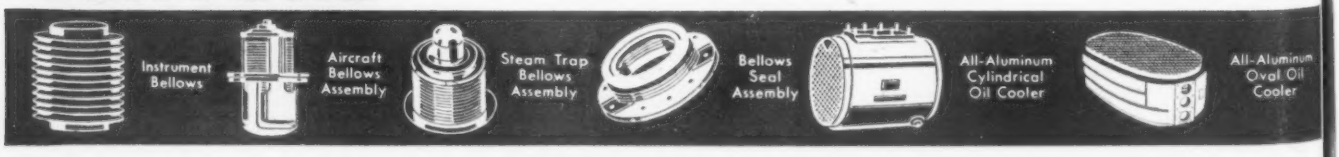
First with the Facts on Hydraulically-Formed Bellows

CLIFFORD HYDRON Metal Bellows

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

Fairchild Wright



TEXROPE F/HP Drives

- **"ENGINEERED" FOR INDUSTRY!**
- **AVAILABLE NOW!**
- **CARRY THE NAME "TEXROPE"... AND OVER 25 YEARS OF EXPERIENCE!**

IF YOU'RE IN THE MARKET for fractional horsepower V-belt drives, here are good reasons for investing in TEXROPE — the greatest name in V-belt Drives. 1) They're "engineered" — selected and applied to suit the exact characteristics of your drive. 2) They're in stock at Authorized A-C Dealers or available promptly through A-C District Offices, and 3) They're backed by the greatest collection of V-belt drive experience and facilities of any company in this business.

TEX-IRON F/HP SHEAVES

High density cast iron. Accurately bored for easy fit with tight shaft grip. Precision grooved for non-slip power and longer belt life. Carefully balanced for vibrationless operation at all speeds.

TEXROPE F/HP V-BELTS

Best known name in V-belts. Carry full rated load with plenty of overload and shock load capacity. Molded to fit sheave groove and grip tightly without excess wear or wasted power. An ideal teammate for Tex-Iron sheaves. Highly efficient on present sheaves, too.

The complete range of Tex-Iron sheaves from 2 to 15 inches PD and Texrope V-belts to match are now available from your dealer's stock. Call him today. Texrope, Tex-Iron, Super 7, Texsteel, Magic Grip and Vari-Pitch are Allis-Chalmers Trademarks.

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

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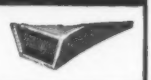
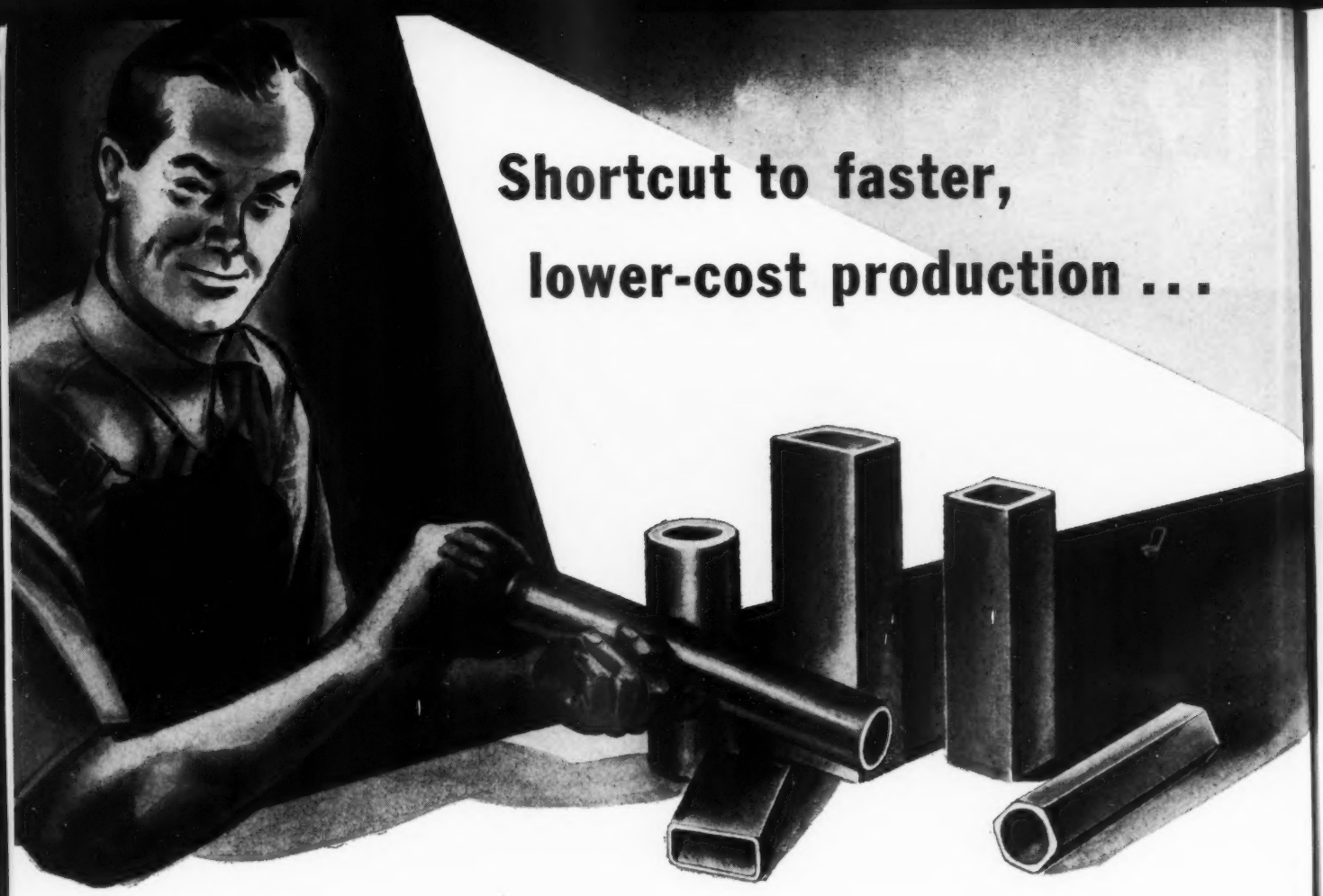
A Complete Range of Products		
Super-7 V-belts	5 types . . . sizes to suit every power transmission job	
Texsteel, Texdrive, Magic-Grip	Sheaves in a full range of sizes and grooves	
Vari-Pitch Sheaves	Exact variations in speed — Stationary or Motion control	
Speed Changers	Speed variations up to 375% at the turn of a crank	

SEND TODAY for Allis-Chalmers 44 page book No. 2086249A describing Texrope F/HP V-belt drives — the Fractional Horsepower Drive that's "Engineered" for Industry. Result of years of experience in engineering FHP V-belt drives. Shows you simple, accurate way to select FHP sheaves and belts. Every FHP drive user should have a copy.

Texrope Super-7 V-belts result from the cooperative research of Allis-Chalmers and B. F. Goodrich; and are sold only by A-C dealers and offices.

ALLIS-CHALMERS

Originators of the Multiple V-belt Drive for Industry



Shortcut to faster, lower-cost production . . .

you start out with the BASIC SHAPE ALREADY MADE *when you use* SHELBY SEAMLESS

SHELBY Seamless Steel Tubing comes to you ready for immediate fabrication or machining.

Made by NATIONAL Tube Company—the world's largest manufacturer of steel tubular products—it is obtainable, in addition to round, in square, rectangular, and other special shapes . . . in any commercial size from ⅜ to 10¼ OD inches, and in wall thicknesses from .035 inch to 1.500 inch cold drawn . . . and in a wide range of steel grades and anneals.

By being able to start with pre-shaped stock instead of with castings or forgings, you eliminate or greatly reduce many time- and labor-consuming operations, as well as the costly waste of material.

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Why not talk to National's engineers about the possibility of using SHELBY Seamless? You, too, may be able to profit by their wide experience. And you can be sure that any recommendations they make will be based on a study of your particular requirements and the results of similar-condition tests in our own laboratories and actual on-the-job observations.

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WALLS WITHOUT WELDS

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UNITED STATES STEEL

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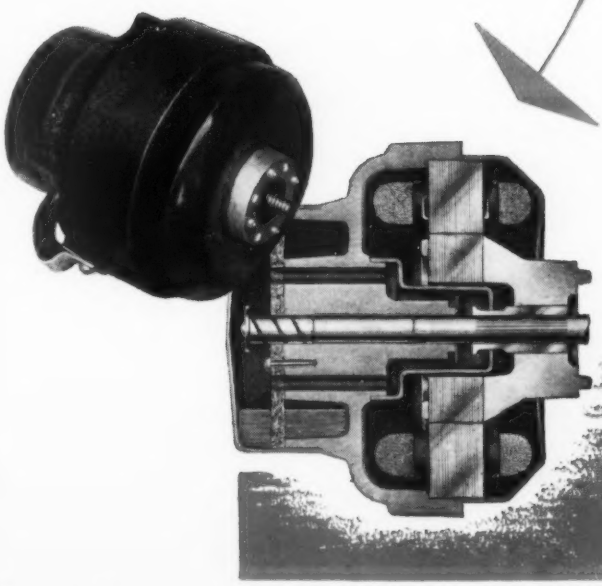
PUT GE UNIT-BEARING MOTORS *on your fans!*

You can control and direct air flow with G-E unit-bearing motors on your fans.

Because they are designed primarily for fan service, G-E unit-bearing motors have the characteristics you want—quiet operation, dependable performance, minimum maintenance, and low cost.

The unique single bearing construction gives you permanent lubrication from a lifetime, sealed oil reservoir. Oil is force-fed along the shaft to flood the bearing constantly for quiet operation. Bearing and stator housing are machined in one set-up for accurate and permanent alignment, dependable operation.

G-E unit-bearing motors are easily adapted to your mountings, use simple, stamped-metal fan blades available from the factory. For immediate delivery of these sturdy, dependable motors, call your nearest G-E sales representative. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*



GENERAL ELECTRIC

Fansteel DEVELOPMENTS

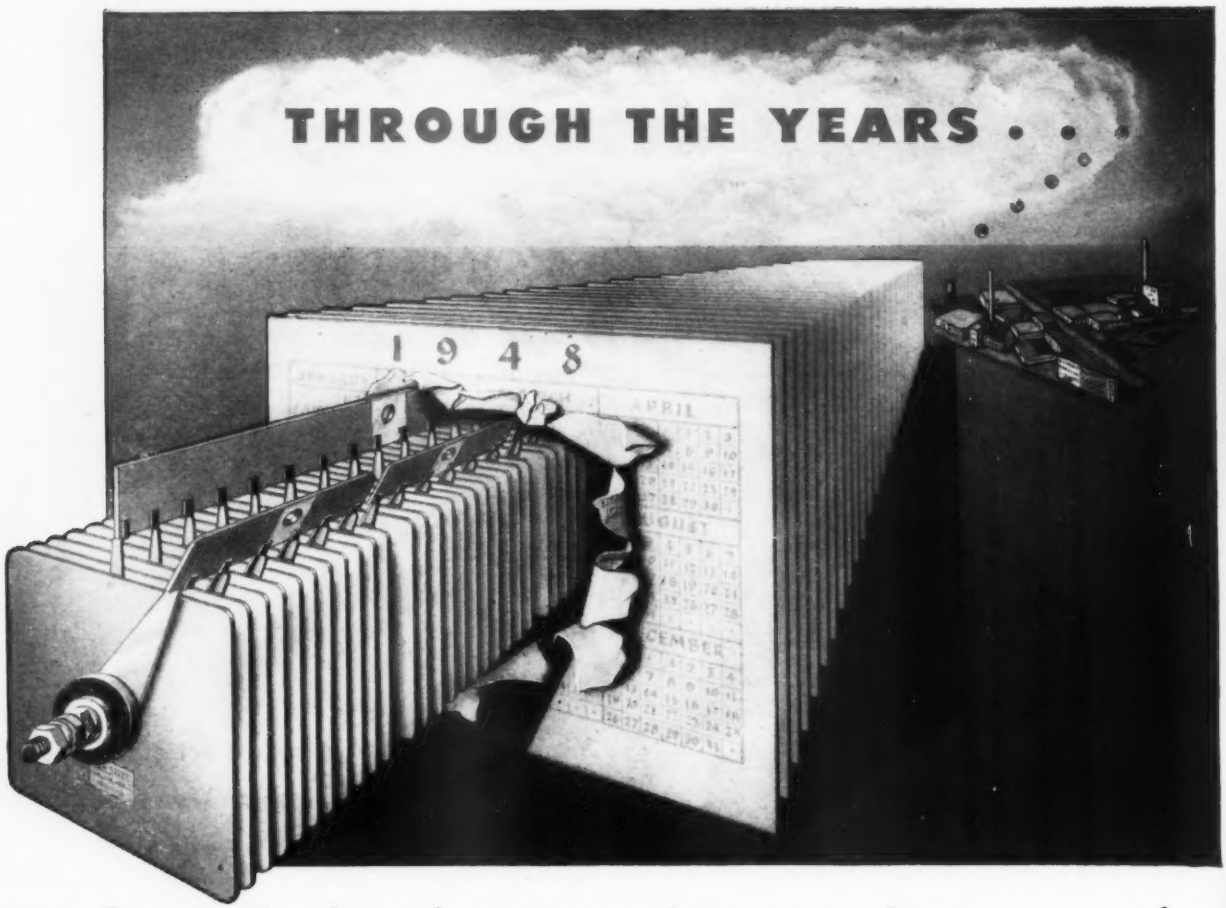


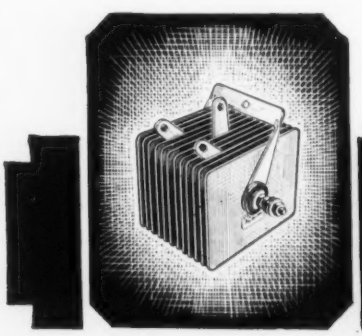
figure largely in the ever-increasing use of

SELENIUM RECTIFIERS

Selenium Rectifiers have made their reputation because experience has proved that they are consistently dependable. The making of good selenium rectifiers not only requires a sound background in electrical engineering and manufacture; it requires knowledge and experience in metallurgy, chemistry and electrochemistry, particularly in the field of unfamiliar elements and materials.

From Fansteel's Code of Aid to Design and Product Engineers

Fansteel's long experience in all these fields is of particular value to you in the matter of selecting, specifying and applying the rectifier best suited to your product. Fansteel Metallurgical Corporation, North Chicago, Illinois.

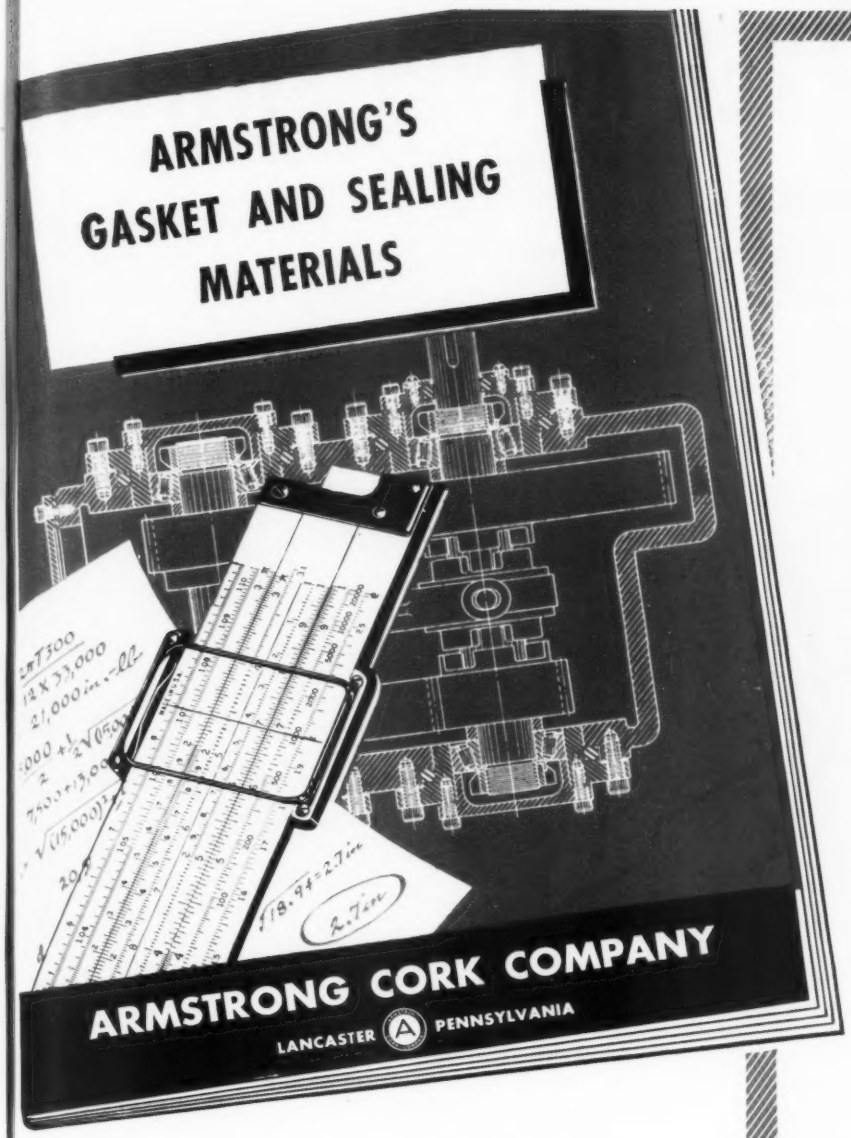


Fansteel

SELENIUM

RECTIFIERS

DEPENDABLE RECTIFIERS SINCE 1924



Send for helpful GASKET GUIDE

If you design, specify, or buy gaskets, you'll find this 24-page gasket guide helpful. "Armstrong's Gasket and Sealing Materials" shows typical applications. It suggests methods of putting Armstrong's stock materials to specialized uses in such fields as the radio, electrical, automotive, petroleum, and transportation industries. It also includes government specifications—plus up-to-date charts on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials. For your free copy, fill in coupon and mail today.

Table of Contents

- Cork Compositions
- Cork Specialties
- Cork-and-Synthetic-Rubber Compositions
- Fiber Sheet Packings
- Synthetic Rubber Compounds
- Stock Materials That Do Specialized Jobs
- Designing Flanges for Efficient Sealing
- Designing Gaskets to Reduce Cost
- Effect of Gasket Width on Compression
- Effect of Surface Condition on Gaskets
- Factors in Choosing Resilient Gaskets
- Proper Compression for Resilient Gaskets
- Relation of Gasket Thickness to Load
- Resistance to Chemicals
- Sealing Oils with Synthetic Rubber
- Sealing with Confined Resilient Gaskets
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Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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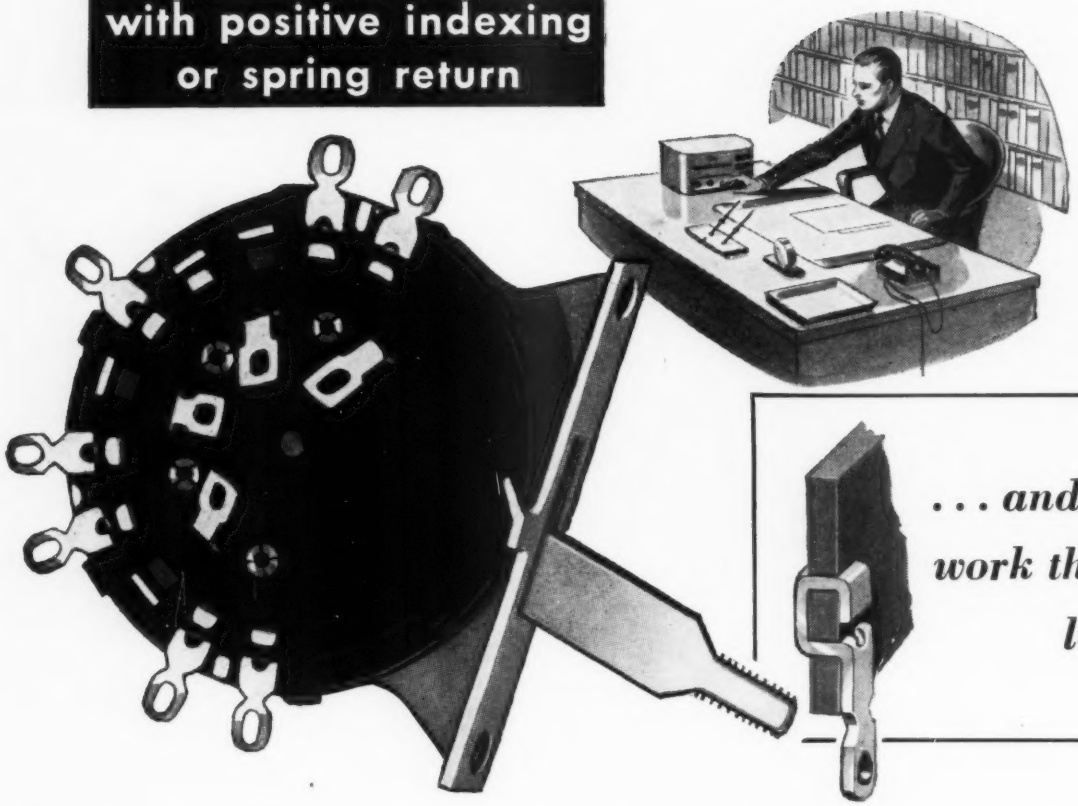
A New, Better LEVER ACTION SWITCH!

with positive indexing or spring return

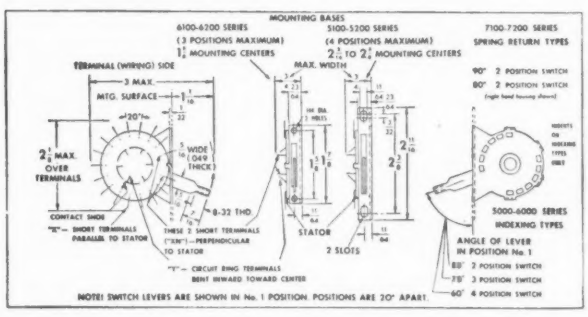


. . . and just try to work this terminal loose!

Although only recently developed and placed on the market, this lever action switch is in big demand. No wonder! It is ideally suited to intercommunications, centralized radio, sound distribution and public address equipment. It gives you a choice of positive indexing *or* spring return. It is as dependable as the leaf spring telephone type switch, yet available at much lower cost.

Consider some of the other "plus" features that set this switch apart: Self-holding terminals of exclusive design are securely clinched to the stator without rivets or eyelets (just try to pull them loose!). All terminals, contacts and ground rings are silver plated for low contact resistance. Constant tension of rotor contact members provides a dependable, self-cleaning action. Insulation is of the highest-grade phenolic.

Positive indexing types of this switch have 48 standard circuit combinations, 24 shorting and 24 positive non-shorting. Spring return types have 17 standard shorting and 17 positive non-shorting circuit combinations. Write for engineering data folder or see your nearest Mallory distributor.



Send for Engineering Data Folder

The Engineering Data Folder for the new Mallory Lever Action Switch contains complete specifications, available circuit combinations with respective terminal locations, dimensional drawings—everything the engineer needs to assist in selection of the particular Mallory Lever Action Switch to best handle the application.

P. R. MALLORY & CO. Inc.

MALLORY SWITCHES

(ELECTRONIC, INDUSTRIAL and APPLIANCE)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

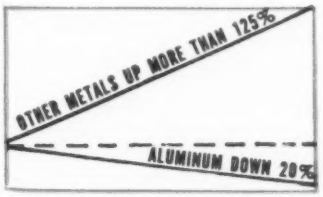
COULD YOUR PRODUCT USE
a loss in weight?
a gain in profit?

TODAY'S bright, beautiful Twin Coach has dropped pounds of dead weight by using a body that is almost 90% aluminum alloys. Bus operators enjoy 40 passenger profit at 30 passenger operating cost. The product is stronger, vibration is reduced, sound-deadening added and styling is enhanced.

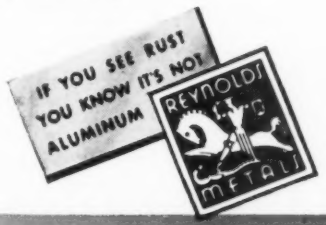
Smart engineering can take advantage of all the benefits offered you by Reynolds Aluminum. For the many forms of aluminum offer endless application. In buses for example—aluminum extrusions for carlings, roll-formed shapes for trim, castings at points of reinforcement, structurals in frame members and sheet for body panels offer important weight reduction and rugged strength.

See how these definite advantages can offer design advancement for your product. Aluminum can't rust, it resists corrosion and cuts finishing costs for the producer—maintenance costs for the customer. There's economy in getting three times the metal to work with because aluminum is ⅓ the weight of ordinary metals. Since it is lighter, aluminum handles faster on production lines and cuts shipping costs. It has greater workability and can be processed rapidly without adding new production equipment in most cases.

It's wise to see what future Reynolds Aluminum holds for your product. Don't pass up profits by letting competition be first to make use of this modern metal. Reynolds technicians stand ready to work with you, so why not call your local Reynolds Sales Office or write to Reynolds Metals Company, Aluminum Division, 2524 South Third Street, Louisville 1, Kentucky.



As a result of Reynolds becoming a primary producer, the base price of aluminum is now 20% below prewar levels.



REYNOLDS *Lifetime* ALUMINUM

REYNOLDS' PIONEERING MADE ALUMINUM COMPETITIVE . . . TAKE ADVANTAGE OF IT!

For "Trouble Free" Service Simplicity Engineering Company Specifies...

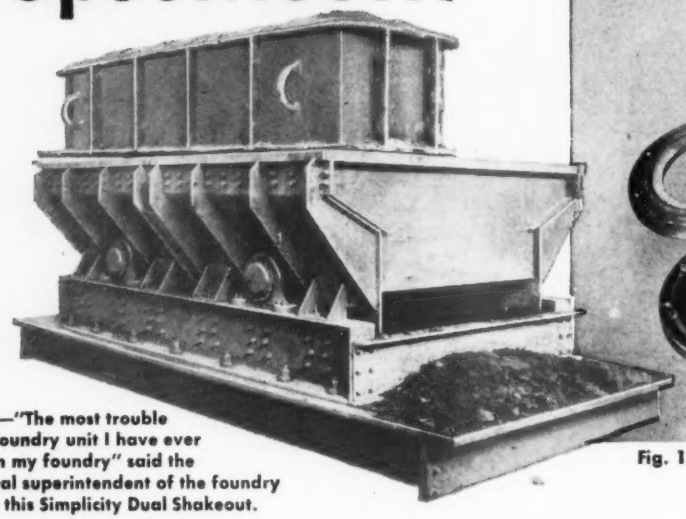


Fig. 2—"The most trouble free foundry unit I have ever had in my foundry" said the general superintendent of the foundry using this Simplicity Dual Shakeout.

Fig. 1—Some of the various Meehanite castings used in Shakeout units.

MEEHANITE® CASTINGS

As BUILDERS of rugged foundry, coal, mining and materials' handling equipment—equipment which gives truly "trouble free" service under severe conditions, Simplicity Engineering Co., Durand, Michigan, use Meehanite castings (Fig. 1) to construct the operating mechanism of units like the 8′ x 10′ Dual Shakeout (Fig. 2).

The castings include:

1. Machine sheave
2. Shaft adapter for mounting sheaves
3. Grease retaining seals
4. Name and cover plate

Produced with the rigid control provided by the Meehanite manufacturing processes, these castings provide *better* engineering properties—contributing to the equipment strength, resistance to wear, toughness, soundess and uniformity.

Write us for a copy of the Meehanite Handbook or send us your prints for an engineering analysis.

Meehanite®

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario
U. S. Challenge Co.	Centerville, Iowa and Batavia, Illinois

"This advertisement sponsored by foundries listed above."

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

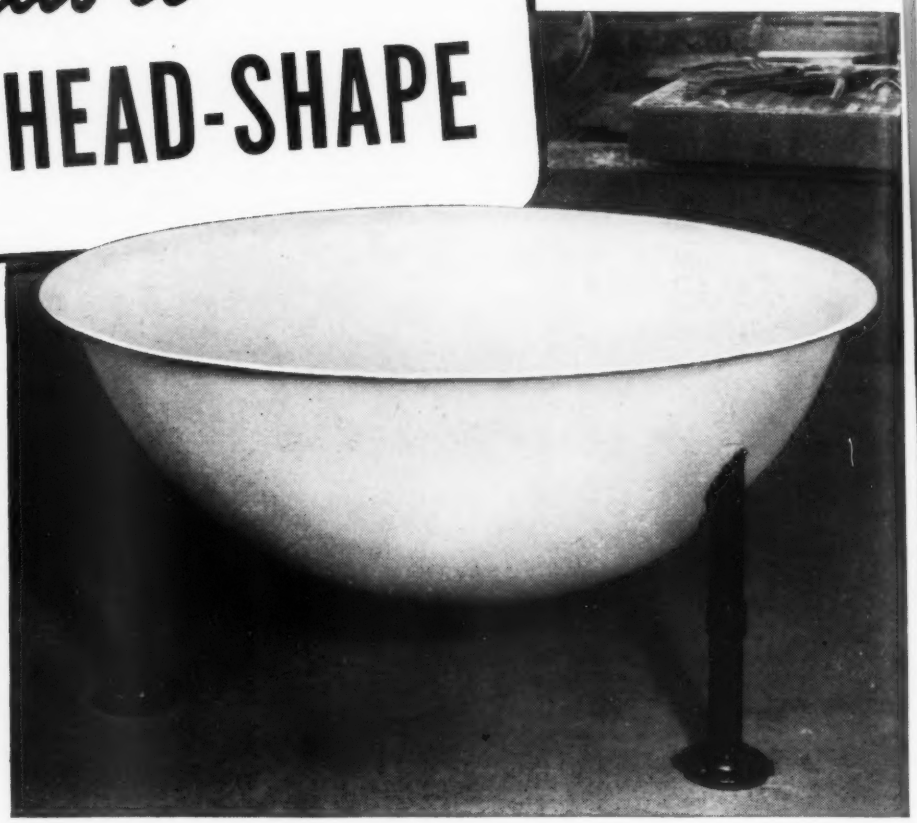
Reynolds weaves... with 53 years' EXPERIENCE

When Horace G. Reynolds started the first wire cloth factory west of New York State, the year was 1894. Reynolds has been a *going* concern ever since . . . consistently going forward . . . to draw better wire, and to weave it into an improved wire cloth. Reynolds has applied its cumulative knowledge . . . gained not only from factory operation and laboratory research, but from direct contact and close co-operation with the nation's leading industries in meeting their wire cloth needs. This 53 years of experience is at your disposal . . . without cost or obligation. Consult Reynolds engineers.

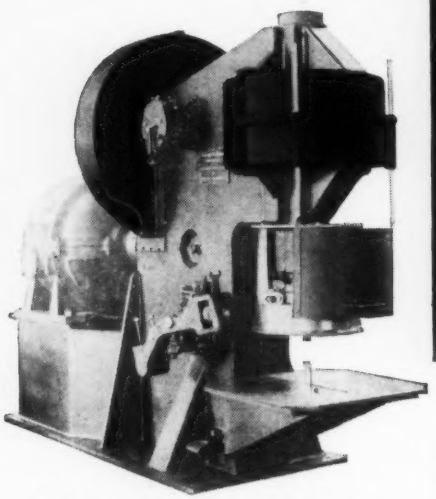
Reynolds Industrial WIRE CLOTH

REYNOLDS WIRE CO., DIXON, ILLINOIS

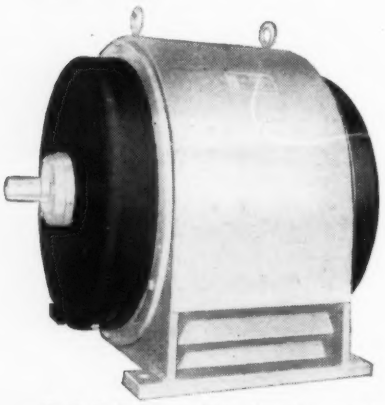
That's a LUKENS HEAD-SHAPE



This evaporating pan, fabricated by Glascote Products, Inc., of Cleveland, using a Lukens Head-Shape, provides stainless steel protection for products requiring chemical purity.



Gear guards on this machine tool were built up from standard Lukens Head-Shapes.



End bells on this electric motor were made from Lukens Head-Shapes.

Glascote Products, Inc., used a Lukens hemispherical Head-Shape, formed and flanged over their special dies and tools by Lukens, to obtain a vessel suiting the requirements for an evaporating pan. The Head-Shape was given a sandblast finish, legs were added and the pan was ready for use.

Hundreds of Lukens Head-Shapes are performing similar service throughout industry. Some are solid stainless, as in this case, whereas others are made of Lukens Clad Steels to lower cost and improve the vessels' heat transfer properties. Others are ordinary steel, copper, aluminum or whatever metal is best suited to the applications.

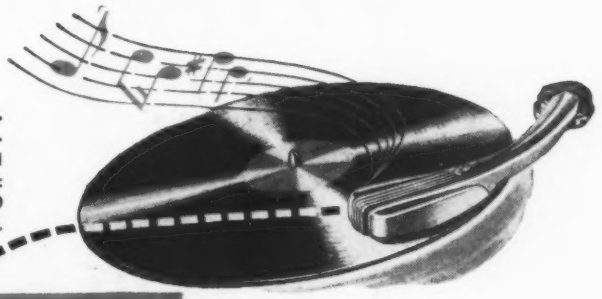
Like other products shown on this page, all have this in common: They started as Lukens Head-Shapes, enabling their manufacturers to begin fabrication without having to do the forming work in their own shops. More products were produced with less plant investment, valuable time was saved and costs were cut.

Catalog No. 1, describing 3,868 standard shapes, will help you decide where Lukens Head-Shapes fit into your products. For a copy and for prices, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

LUKENS HEADS

FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •



The G-E Electronic Reproducer, which magnetically recreates the full recorded sound, derives its magnetic field from a G-E SINTERED ALNICO 5 permanent magnet.

Announcing... A NEW G-E DEVELOPMENT SINTERED ALNICO 5

Actual size of G-E SINTERED ALNICO 5 permanent magnet used in the G-E Electronic Reproducer is shown in red.

NEW ENGINEERING DEVELOPMENT

SINTERED ALNICO 5, General Electric's newest magnetic material, now enables you to design intricate shapes with higher external energy than ever before. The minimum guaranteed available energy is 3,500,000 gauss oersteds for most sizes and shapes. New G-E SINTERED ALNICO 5 possesses tensile properties several times those of CAST ALNICO 5 and can be produced economically in small size parts. You get better surface finish plus closer dimensional tolerances with new G-E SINTERED ALNICO 5.

NEW DESIGNS POSSIBLE

New SINTERED ALNICO 5 has higher external energy than either SINTERED ALNICO 2 or 4. This makes possible new designs heretofore impossible or impractical. It is especially adaptable where small powerful magnets having high magnetic properties are required. Because of their great stability and external energy, SINTERED ALNICO 5 magnets can save valuable space in your product. You can usually improve your product by re-designing to use high energy G-E SINTERED ALNICO 5. Typical applications now in production which use G-E SINTERED ALNICO 5 include the following: meters, relays, fountain pens, electronic reproducers, and compasses.

ENGINEERING SERVICE

G-E application and development engineers, working closely together, are ready to advise you on new SINTERED ALNICO 5 and other G-E magnetic materials. Our engineers are backed by years of research and the development of thousands of magnetic applications. They will be glad to work with you on your product design. For more information, please mail the coupon shown below.

YOU GET 5 ADVANTAGES

1. Higher external energy than either SINTERED ALNICO 2 or 4.
2. Tensile properties are several times greater than CAST ALNICO.
3. Excellent surface finish.
4. Close dimensional tolerances.
5. Intricate shapes possible.

METALLURGY DIVISION
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.
Please send me:
( ) Technical Report on new SINTERED ALNICO 5.
( ) Bulletin, CP-12, "G-E Permanent Magnets."
NAME..... TITLE.....
COMPANY.....
PRODUCTS MFRD.....
ADDRESS.....
CITY..... STATE.....

PERMANENT MAGNETS

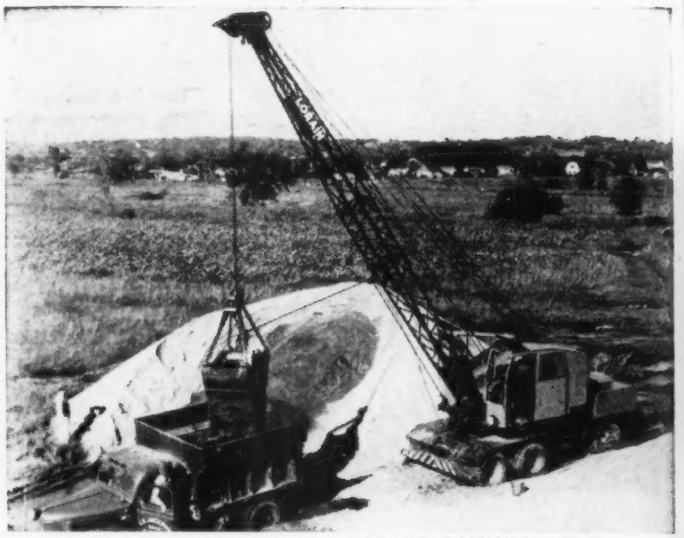
GENERAL ELECTRIC

CD48-V2

TAGLINES OR DIPPER-TRIPS--

WARNER ICB UNITS*

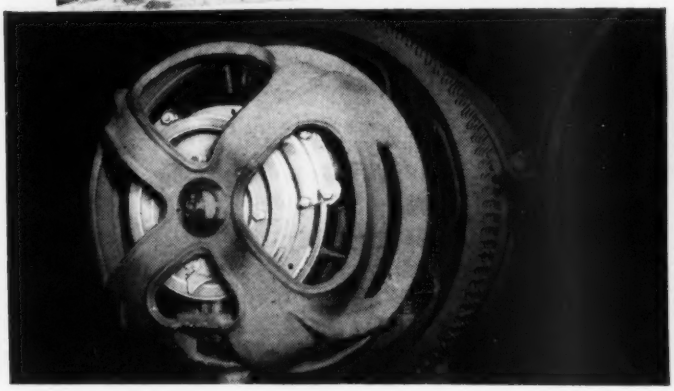
GIVE YOU FASTER, MORE ACCURATE CONTROL



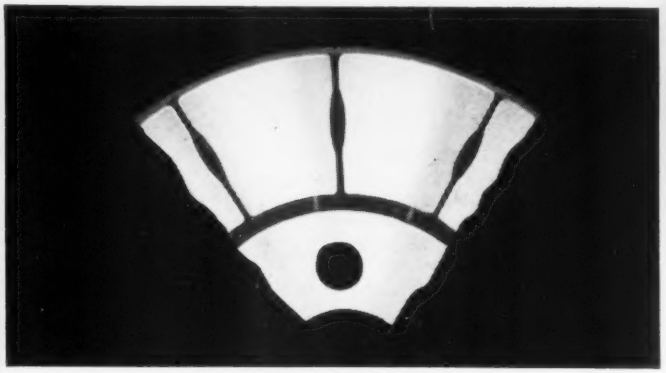
LORAIN CLAMSHELL. Tagline Controlled by Warner ICB Unit.

LORAIN SHOVEL — Warner ICB Unit equipped

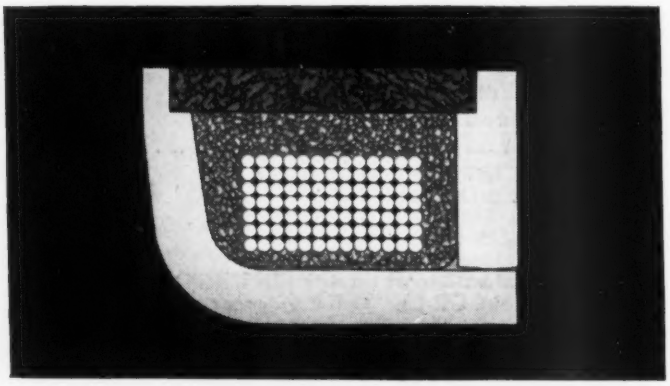
THEW-LORAIN SHOVELS AND CRANES USE a Warner Electric Industrial ICB Unit* on the tagline and dipper-trip reel. It continuously maintains exact tension to precisely position a clamshell or magnet and keep them steady without twisting. Flexibility of control permits a larger working area without repositioning machine or boom. When used with a shovel — it keeps dipper-trip line constantly taut and trips dipper at finger touch.



WARNER ICB UNIT* AS INSTALLED on Thew Shovel. Note simple compactness, easy accessibility. ICB Units are self-adjusting for life. Push-button and rheostat give instant finger-tip control. There's a complete range of sizes to meet various requirements for positive acting, sensitive controlled clutches or brakes for industrial use.



ARMATURE SECTION: One of only two parts for either Clutch or Brake actuating units. Consists of magnetic segments welded to steel back-plate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . thus keeping full magnet contact at all times.



MAGNET SECTION: The other of the two parts for either Clutch or Brake actuating units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut) uses both friction plus magnetic attraction for lightning fast, super-powerful clutch or brake action.

● Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: Industrial Division, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

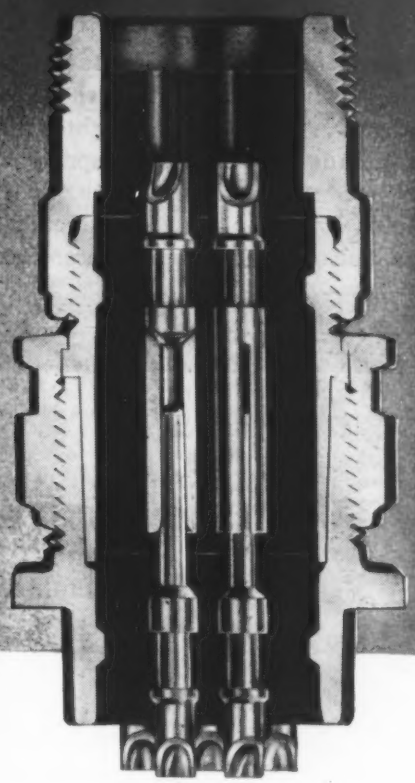
WARNER
ICB UNIT*

*ICB Unit — The trade designation for The Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.

BENDIX-SCINTILLA

ELECTRICAL CONNECTORS

the finest money can buy!



these are the features THAT HAVE MADE IT *the* QUALITY CONNECTOR

- Moisture-proof, Pressure-tight
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Arc Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector

and THIS IMPORTANT ADVANTAGE—

PRACTICALLY NO VOLTAGE DROP!

Contacts that carry maximum currents with a minimum voltage drop are only part of the many new advantages you get with Bendix-Scintilla* Electrical Connectors. The use of "Scinflex" dielectric material, an exclusive new Bendix-Scintilla development of outstanding stability, increases resistance to flashover and creepage. In temperature extremes, from −67° F. to +300° F., performance is remarkable. Dielectric strength is never less than 300 volts per mil. Bendix-Scintilla Connectors have fewer parts than any other connector on the market—and that means lower maintenance costs and better performance.

*TRADEMARK

Available in all Standard A.N. Contact Configurations.
Write our Sales Department for detailed information.

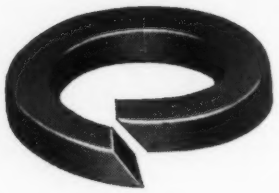
BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of
SIDNEY, NEW YORK

Bendix
AVIATION CORPORATION

RELIANCE SPRING LOCK WASHERS

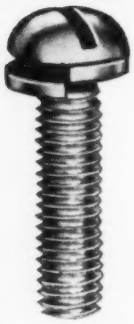
for dependable, enduring bolt tightness



Compact, inexpensive, Reliance Spring Lock Washers act as hardened thrust bearings . . . make possible tighter assemblies. Made of cold drawn spring steel, their powerful coil-spring tension compensates for wear and bolt stretch . . . keeps bolted assemblies tighter longer.

3 ways to

- **CUT COSTS**
- **SPEED PRODUCTION**
- **IMPROVE PRODUCTS**



EATON SPRINGTITES

speed assemblies

cut costs

Eaton Springtites are quality Reliance Spring Lock Washers pre-assembled on bolts or screws so they can't come off. They speed assemblies, eliminate loss, prevent use of wrong washer, simplify inventories—cut costs.

RELIANCE RINGS

cut machining time

reduce material costs

Reliance Rings snap into grooves in shafts or counterbores, forming strong shoulders without tedious, costly machining and waste of material. Easily removed when necessary. Open or welded, any diameter, cross section or end cut.

EATON

EATON MANUFACTURING COMPANY

Reliance Division

OFFICES AND PLANT **MASSILLON, OHIO**

Sales Offices: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

Micarta . . .

TOUGH WHEN THE HEAT'S ON!

When things get hot, Micarta—today's workable, industrial laminate—stands solid and unharmed in temperatures up to 230 degrees F. At zero and below—it actually increases in strength—with *no brittleness*. Micarta is no ordinary "plastic". It's a product which has proved to be the answer in hundreds of material needs in many industries.

Micarta has a combination of qualities which may solve the *materials problem* in your new (or old) product. In addition to heat resistance—it has:

HIGH STRUCTURAL STRENGTH—Half as heavy as aluminum with the same compressive strength.

REDUCES NOISE—absorbs vibration.

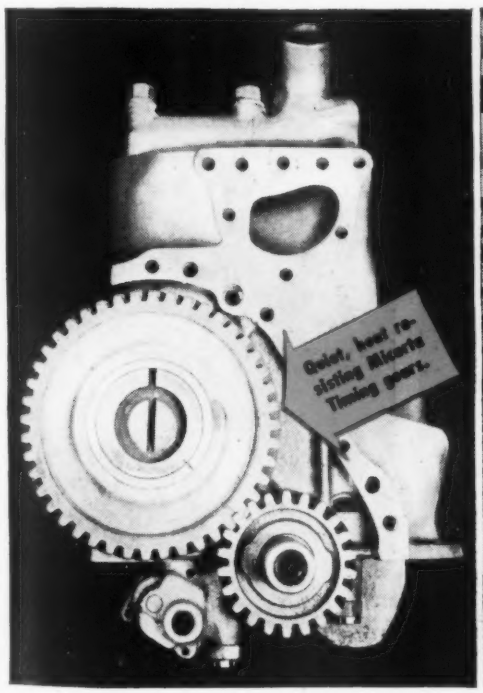
HIGH CORROSION RESISTANCE—unharmed by 10% solutions of most acids and alkalis. Resists oil and water absorption, too.

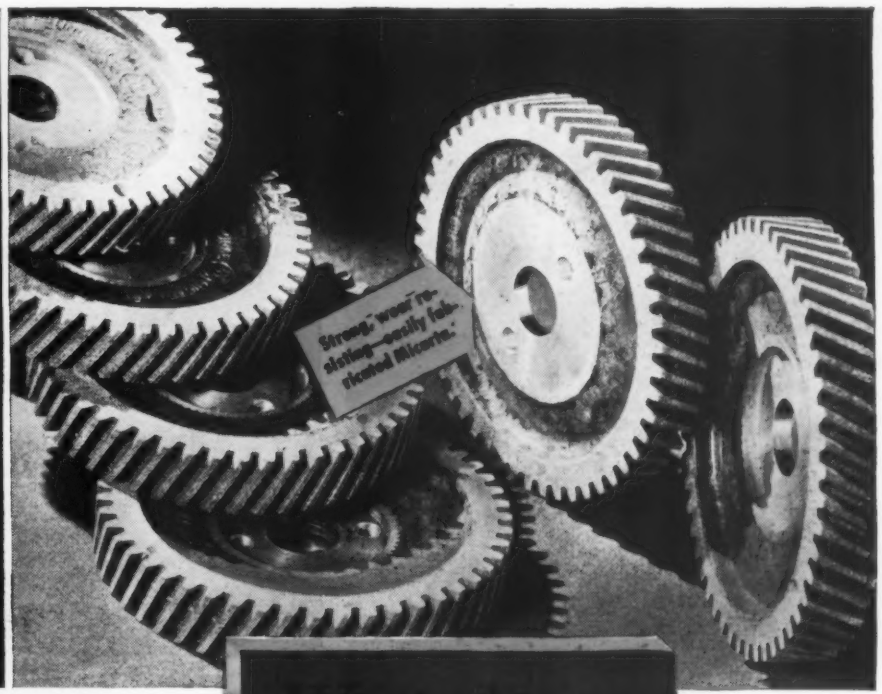
HIGH WORKABILITY—can be machined to close tolerances, drilled, thread tapped, sawed or die punched.

WITHSTANDS VIBRATION—"cushions" shock and severe vibration.

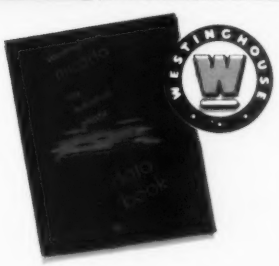
Design engineers have unlimited possibilities in Micarta. In various grades, Micarta can be completely *fabricated* in *mass production quantities*. The finished Micarta is shipped ready to apply.

When you have a tough material problem, remember *Micarta!* Call your Westinghouse office or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-06397





Send for this new Micarta Data Book today. Ask for B-3184-B.



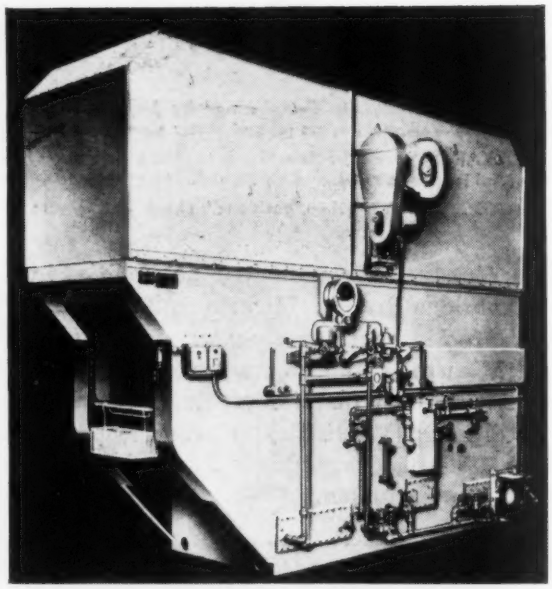
Westinghouse

Micarta

THE INSPECTED LAMINATE

Tough on the grease...

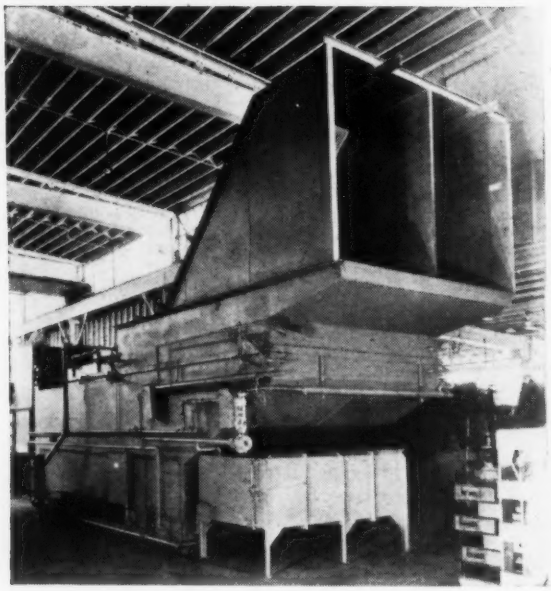
BUT EASY ON THE EQUIPMENT

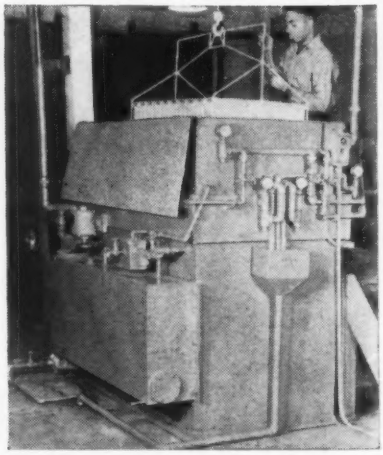


Solvents employed in metal-cleaning remove grease in a hurry. Some solvents are highly corrosive. That is why Lukens Clad Steels with *extra*ordinary corrosion-resisting properties are so widely used for this equipment today.

Nickel is able to withstand attack of warm, chlorinated solvents. Used as a clad steel, in which nickel is usually only 10% or 20% of total plate thickness, this corrosion-resistant metal takes the full brunt of the attack. The equipment shows *clad* steel economies although providing *solid* nickel performance.

Lukens Clad Steels—Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad—are available in plates as wide as 178″. Specify the corrosion-resisting metal which meets your own degreasing requirements in a money-saving clad steel. For further data, write for Bulletins 255 and 338, Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.





Small hand-operated tanks or huge vapor degreasers, all are made of corrosion-resisting Lukens Clad Steels.

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

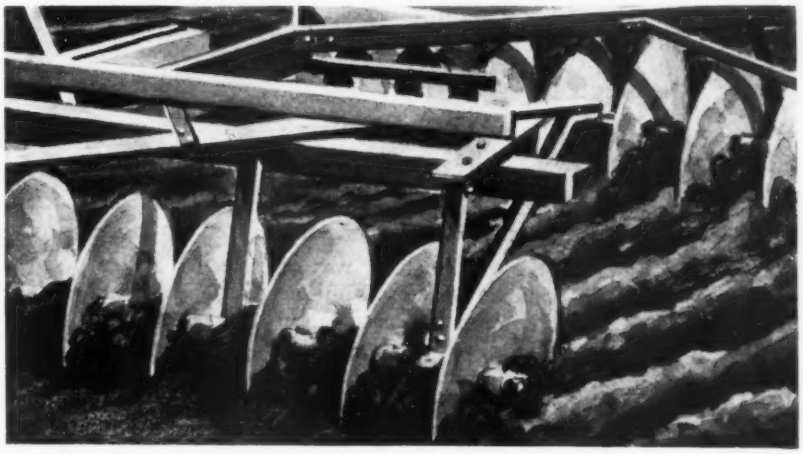
SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

NATIONAL OIL SEAL LOGBOOK

NEW DUAL TYPE OIL SEAL FOR DISC PLOWS SOLVES DIFFICULT DIRT EXCLUSION PROBLEM

The development of special abrasive resistant sealing member makes it possible to utilize the more rugged spring-loaded type oil seal instead of the fine tolerance face types formerly thought necessary for disc plow applications. Their successful use under these extreme conditions is indicative of what this new oil seal can do for many extreme applications such as found on tractors and others.



DUAL TYPE SEAL

The oil seal utilized for disc plows is basically of a standard double wipe design. However, the actual sealing members are of special shape so as to withhold the unusual amounts of heavy abrasive muck and dirt encountered. The sectional drawing (Fig. 1) shows detail of the new seal. The outer sealing lip (a) is of particularly tough compound bonded rigidly to the inner case. The inner lip (b) is of unusual shape and is seated with tensioning spring.

SEALING LIP IS REVERSED

Contrary to most spring-loaded seals this one is designed so the sealing lip faces externally. This is done deliberately because the pressure of external abrasive is generally higher than the pressure of lubricant in the bearing. This also protects the assembly against inexpert lubrication. Lubricant may be forced completely through the bearing without damaging the seal. Furthermore, such forced lubrication acts to flush out the bearing and housing area.

Figure 1

LABORATORY RESEARCH HELPED SOLVE THIS PROBLEM

At the National laboratory, many variations of oil seal designs were thoroughly tested out under simulated working conditions which were actually more rugged than could ever be encountered. This first-hand experimentation made it possible for National to contribute much to the successful and economical use of friction-free bearings in disc plows. In addition, this pre-application testing pointed the way for improving mechanical design of shrouding and mountings. For detailed information or assistance in solving oil sealing problems, National Engineers are at your service.

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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CLEVELAND: 210 Heights Rockefeller Building, Yellowstone 2720. **DALLAS:** 30½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-6363. **HOUSTON:** 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384. **MILWAUKEE:** 1717 E. Kane Place, Lakeside 2838.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260. **PHILADELPHIA:** 401 North Broad Street, Bell-Walnut 2-6997.
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EAST SYRACUSE, N. Y.: 226 Roby Avenue, East Syracuse 366. **WICHITA:** 340 North St. Francis Street, Wichita 2-6971.

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This should give you ideas

Ever since Bead Chain† was introduced, its use has grown.

But the manufacturer was not satisfied. Still *more* sales could be made if his unique flexible chain were available in a metal that would resist corrosion by marine atmospheres, salt water, high-test gasoline, corrosive factory fumes . . . a metal strong enough to be trusted for use as control cables on numerous devices . . . a metal that would not rust, would always stay bright and attractive . . . a metal that—the list went on and on.

Finally, the manufacturer decided to add another metal to his line. The new chain would be stronger, tougher, corrosion-resisting and rustless.

Bead Chain engineers started their search. Complicating their task was a basic "must"... ductile workability. *(The chain is formed entirely from strip!)*

Investigating all likely metals, they finally selected Monel*. This Inco Nickel Alloy offered all the properties demanded for a hard-service, long-life chain. Its easy workability permitted it to be formed on existing production machinery.

With Bead Chain available in Monel, sales boomed. The dog leash shown above is but one of many new uses. Monel Bead Chain also is used as a retaining chain for the gas-tank cap on outboard motors . . . light and ventilator pulls . . . control cables . . . electric fixture suspension chains . . . cable for remote position indicators . . . swivels, leaders, leads for fishermen.

† T. M., Bead Chain Mfg. Co., Bridgeport 5, Conn.

INCO Nickel Alloys

Monel • "R"* Monel • "K"* Monel • "KR"* Monel • "S"* Monel Nickel • "L"* Nickel • "Z"* Nickel • Inconel* *Reg. U.S. Pat. Off.*

"Task Metals" for Industry

EMBLEM OF SERVICE INCO TRADE MARK

DO YOU GET IDEAS *from this use of Monel? Perhaps, like Bead Chain Mfg. Co., you have a metal selection problem. If so, investigate Monel and the other Inco Nickel Alloys. They're real "task metals," ready to take on your tough jobs. Pass your metal problems on to us. Our Technical Service staff will be glad to make recommendations.*

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67 Wall Street, New York 5, N. Y.

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Aluminum Stampings, Assemblies and Other Fabricated Parts Produced by Specialists in Reynolds Modern Plants

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Take advantage of HYATT Experience

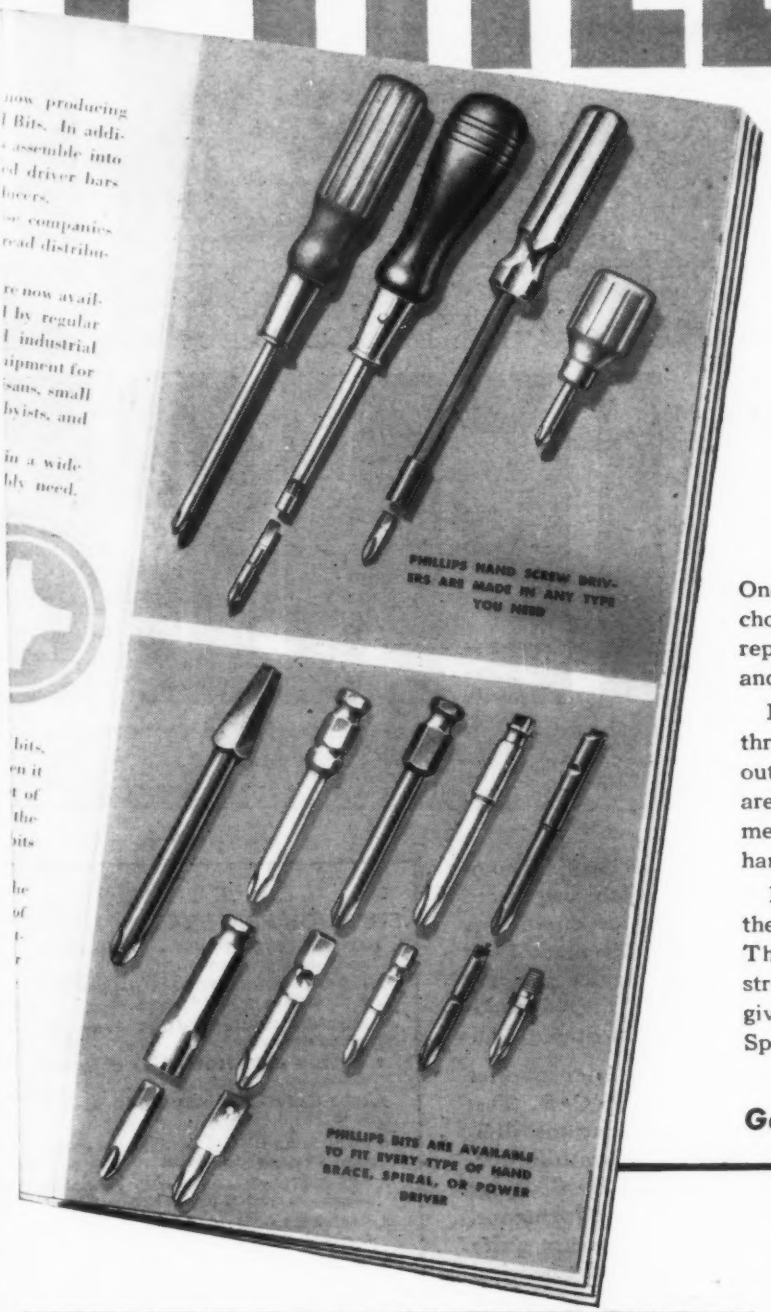
As builders of the first, and today the finest roller bearings, Hyatt, in more than half a century, has accumulated a lot of application experience which should be helpful to you.

Hyatt engineers are at your service, glad to assist you in solving your bearing problems whether you are designing a new machine or piece of equipment or modernizing an existing design.

Hyatt Roller Bearings are used by thousands of leaders in the automotive—industrial—agricultural—petroleum—construction and transportation fields. Costs you nothing to invite a Hyatt man to confer with you. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

HYATT ROLLER BEARINGS

ONLY PHILLIPS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Resilient parts made from HYCAR synthetic rubber *stay* resilient. That's partly because of HYCAR's unusual chemical stability—its resistance to oil and gas, acids and most other chemicals. And parts made from HYCAR are extremely resistant to the effects of oxidation, sunlight, and normal aging. A HYCAR sealing ring, for example, will maintain a positive seal through years of service even when constantly exposed to oils and acids inside the pipe, and sunlight and salt air outside.

Other unusual and valuable properties are listed in the box at the right. But most important, these properties may be had in an almost limitless number of combinations, each designed to meet the specific service conditions of the finished part. Parts made from HYCAR have seen service in *every* industry, giving long life, dependability, and economical operation.

That's why we say ask your supplier for parts made from HYCAR. Test them in your own applications, difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. For more information, please write Dept. HO-12, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

CHECK THESE SUPERIOR FEATURES OF HYCAR

1. *EXTREME OIL RESISTANCE — insuring dimensional stability of parts.*
2. *HIGH TEMPERATURE RESISTANCE—up to 250° F. dry heat; up to 300° F. hot oil.*
3. *ABRASION RESISTANCE—50% greater than natural rubber.*
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8. *HARDNESS RANGE—compounds can be varied from extremely soft to bone hard.*
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THE NEW TYPE AH *

combination MOTOR STARTER for high-voltage motors with

new longer life

Here is the answer to severe "repeater" duty motor starting—a combination starter for high-voltage motors that assures instant protection . . . that stands up to millions of start-stop operations with minimum maintenance!

Gives Years of Tough, Repetitive Service

New, longer life operation, new freedom from maintenance is made possible by the heavy-duty Westinghouse Air-Break Contactor. Because it operates in air instead of oil, the new Type AH Contactor increases contact life . . . reduces maintenance to routine checkups. Rating: 5000 volts maximum.

Limits Fault Currents in .002 seconds

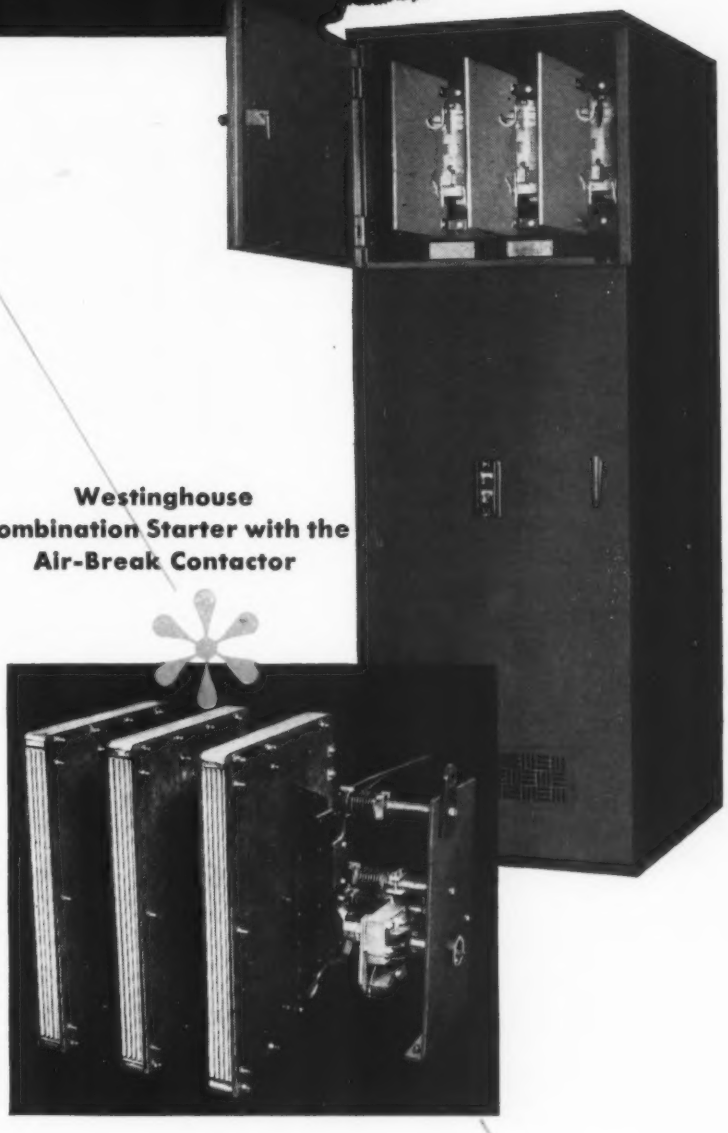
Fast-acting Type BAL Fuses protect the circuit against faults beyond the interrupting capacity of the contactor . . . limit fault currents in ⅛ cycle . . . completely clear them in ½ cycle. Interrupting capacity: 150,000 kva at 2300 volts; or 250,000 kva at 4160 volts, 3 phase, 60 cycles.

Installs Fast and Easy

One all-welded steel cabinet houses the starter and circuit protective components. On-the-job wiring is limited to making connection to line and motor. Standardized cabinets make attractive single or group installations and simplify future addition of control units.

Get the complete facts. Contact your nearby Westinghouse representative today or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-60661

Send for bulletin B4023



Westinghouse Combination Starter with the Air-Break Contactor

- New, longer life, heavy-duty Air-Break Contactor
- Millions of trouble-free operations
- Maintenance minimized . . . contact life extended . . . no oil to check or replace
- Exclusive arc interrupter design eliminates continuous blowout-coil losses

Westinghouse

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Industrial Controls

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Allocated Silver on WIRE

Where you need it—

"Why put silver where you don't need it!"

General Plate Laminated Silver on base metal wire gives you all the performance advantages of solid silver wire yet the cost is exceptionally less. It means that you now can get wire with silver exactly where you need it, thus providing economies not possible with expensive solid silver wire.

General Plate Laminated Silver wire is available in a wide range of shapes and in practically all diameters. Through long years of manufacturing know-how an extremely accurate thickness of silver is maintained throughout the entire length of the wire. Uniform, even temper is assured with strand annealing.

Among the types of General Plate Laminated wire obtainable are odd shapes, solder-filled, channel, solder-flushed, ornamental, squares, flats and ovals. For specific designs and applications pertaining to your problems, we invite you to consult General Plate engineers. Write for their services and information.

I-648

GENERAL PLATE DIVISION

of Metals and Controls Corporation

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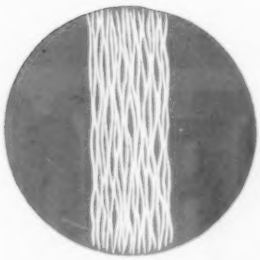
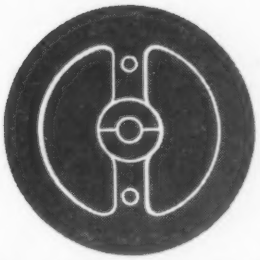
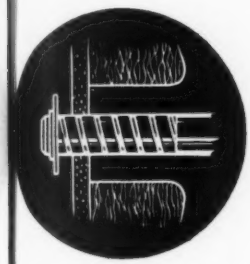
50 Church St., New York, N. Y. • 205 W. Wacker Drive, Chicago, Ill. • 757 W. Third St., Mansfield, Ohio • 36 Eastern Ave., Pasadena, Calif.



Special inorganic fiber packing . . . high in oil-holding capacity!

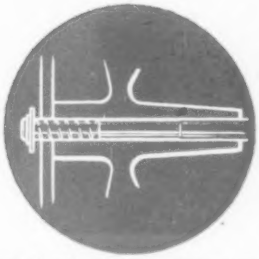


Extra large oil reservoir . . . isolated from heat, permanently sealed!



Forced recirculation of lubricant . . . for long, service-free operation!

NEW *Redmond* SINGLE BEARING, SHADED POLE MONOMOTORS



Precision finished single bearing . . . extra long for true shaft alignment and free running rotor!

Here are the features you want . . . the features you need in single bearing fractional horsepower electric motors. Brought to you now in the new Redmond MonoMotor . . . 4-pole shaded pole, up to 9 watts output. Designed and built to give you outstanding performance over years of smooth, quiet, service-free operation. Look! ☆ Extra large oil reservoir . . . isolated from heat and permanently sealed. ☆ Special inorganic fiber packing . . . dependable oil release, improved lubricating action. ☆ Forced feed lubrication of bearing surfaces by means of spiral pump on shaft. ☆ Extra long, precision finished single bearing for accurate sustained rotor alignment. Then add varnish sealed windings for humidity resistance and cooler operation, die cast aluminum rotor, and a rugged cast iron case. There you have a perfect little low-range power unit designed to out-last your longest expectations. Mounting brackets available, too, for simplified installation. Write today for details.

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OFFICES IN NEW YORK, CHICAGO, DAYTON, LOS ANGELES, DALLAS

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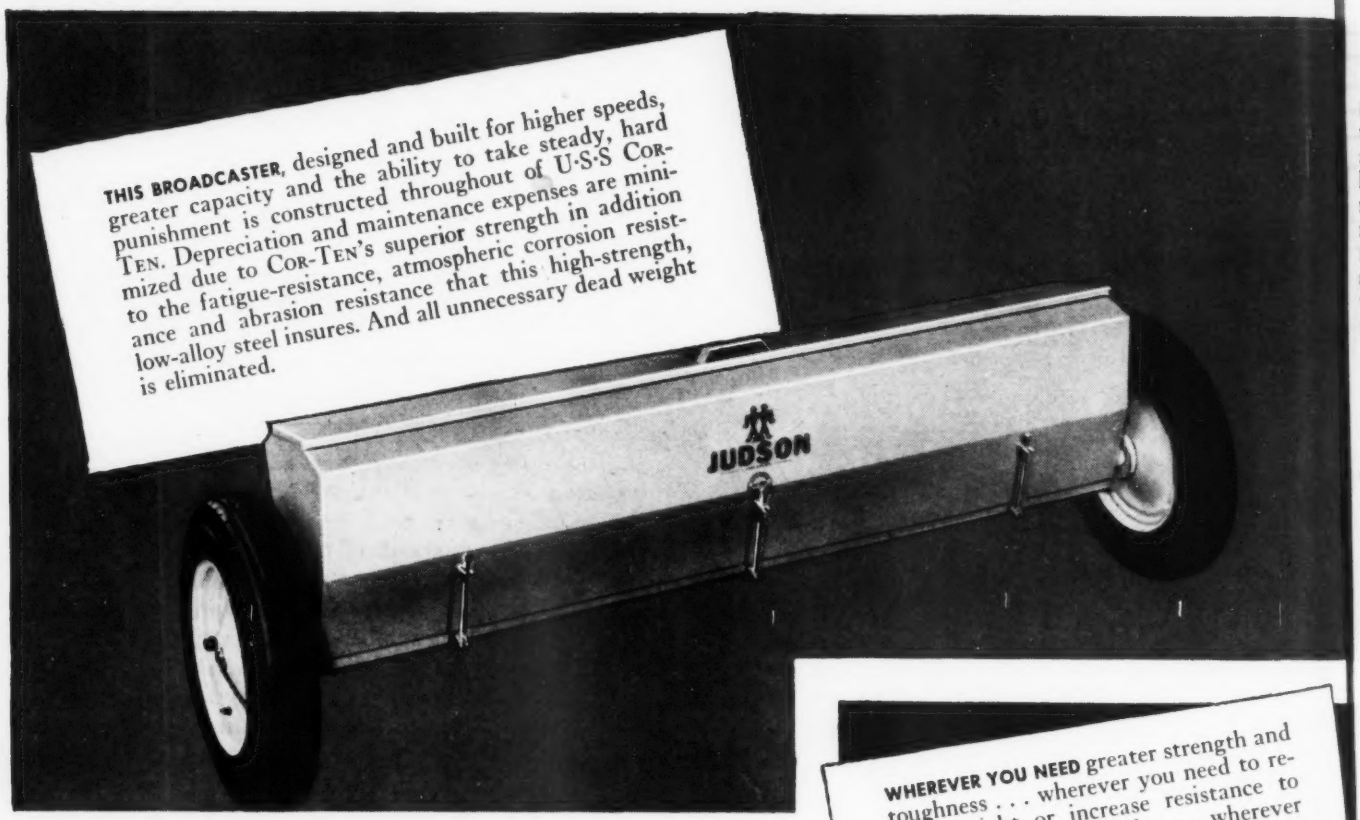
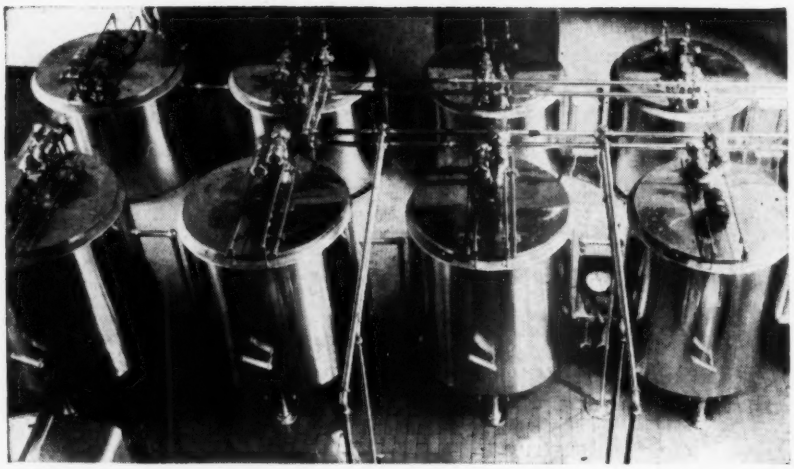
Because STEEL gives the greatest freedom in design and fabrication

9 TIMES OUT OF 10, STEEL



THIS BROADCASTER, designed and built for higher speeds, greater capacity and the ability to take steady, hard punishment is constructed throughout of U·S·S COR-TEN. Depreciation and maintenance expenses are minimized due to COR-TEN's superior strength in addition to the fatigue-resistance, atmospheric corrosion resistance and abrasion resistance that this high-strength, low-alloy steel insures. And all unnecessary dead weight is eliminated.



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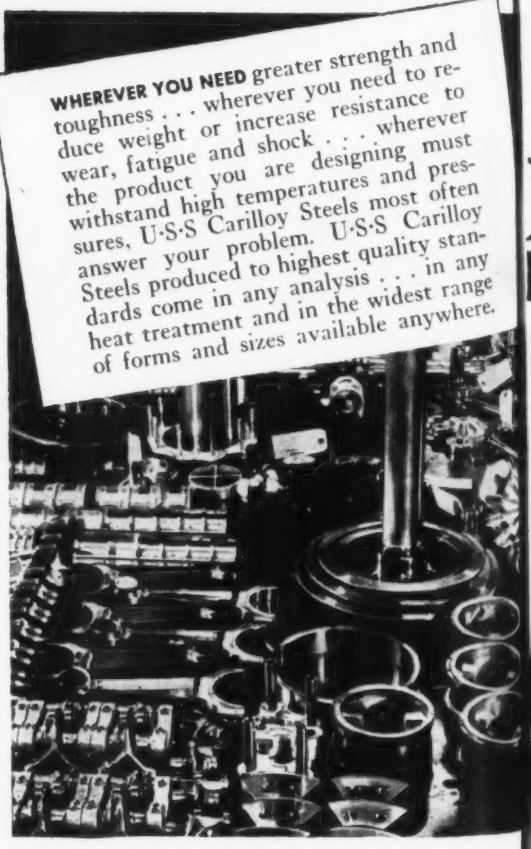

WHEREVER YOU NEED greater strength and toughness . . . wherever you need to reduce weight or increase resistance to wear, fatigue and shock . . . wherever the product you are designing must withstand high temperatures and pressures, U·S·S Carilloy Steels most often answer your problem. U·S·S Carilloy Steels produced to highest quality standards come in any analysis . . . in any heat treatment and in the widest range of forms and sizes available anywhere.

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U·S·S COPPER STEEL provides *twice* the atmospheric corrosion resistance of regular steel and at very low additional cost. This higher resistance to atmospheric corrosion makes it superior construction for roofs, as shown here, as well as for water storage tanks, refrigerating equipment, ventilating equipment, metal cabinets and automotive parts.

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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

FACTS *to help you solve your design problems with U·S·S Steels*

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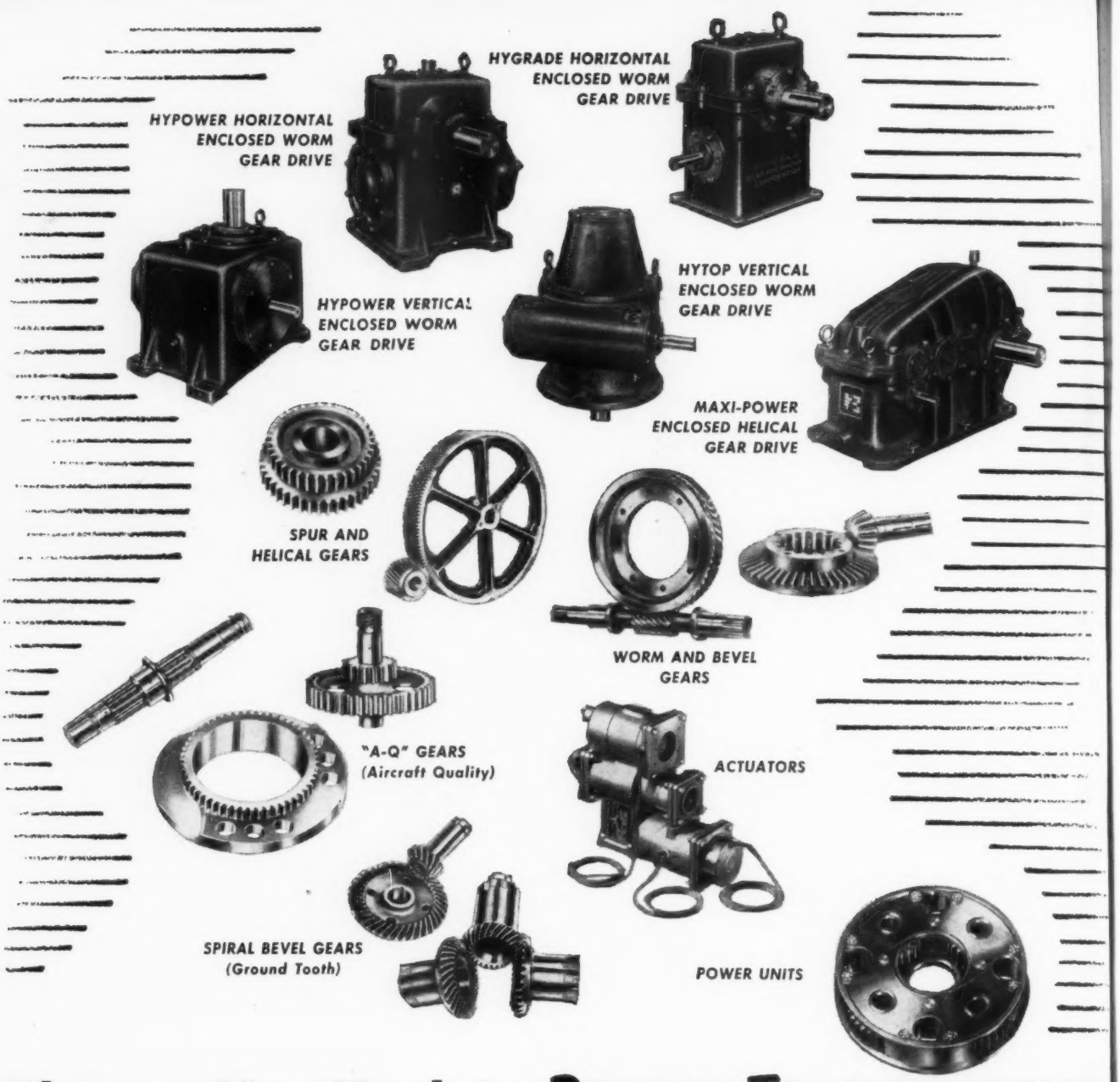
UNITED STATES STEEL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If the equipment you manufacture calls for high quality gears, Foote Bros. has facilities for producing helical, worm, spur, and bevel gears in practically any size and ratio.

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If you are looking for enclosed gear drives—worm or helical—Foote Bros. has a complete line in a wide variety of sizes and ratios. The new Hypower Worm Gear Drives and Maxi-Power Helical Gear Drives offer the latest engineering development.

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Foote Bros.' plants offer the latest equipment for producing of gears and enclosed gear drives—backed by almost a century of manufacturing experience.

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Better Power Transmission Through Better Gears

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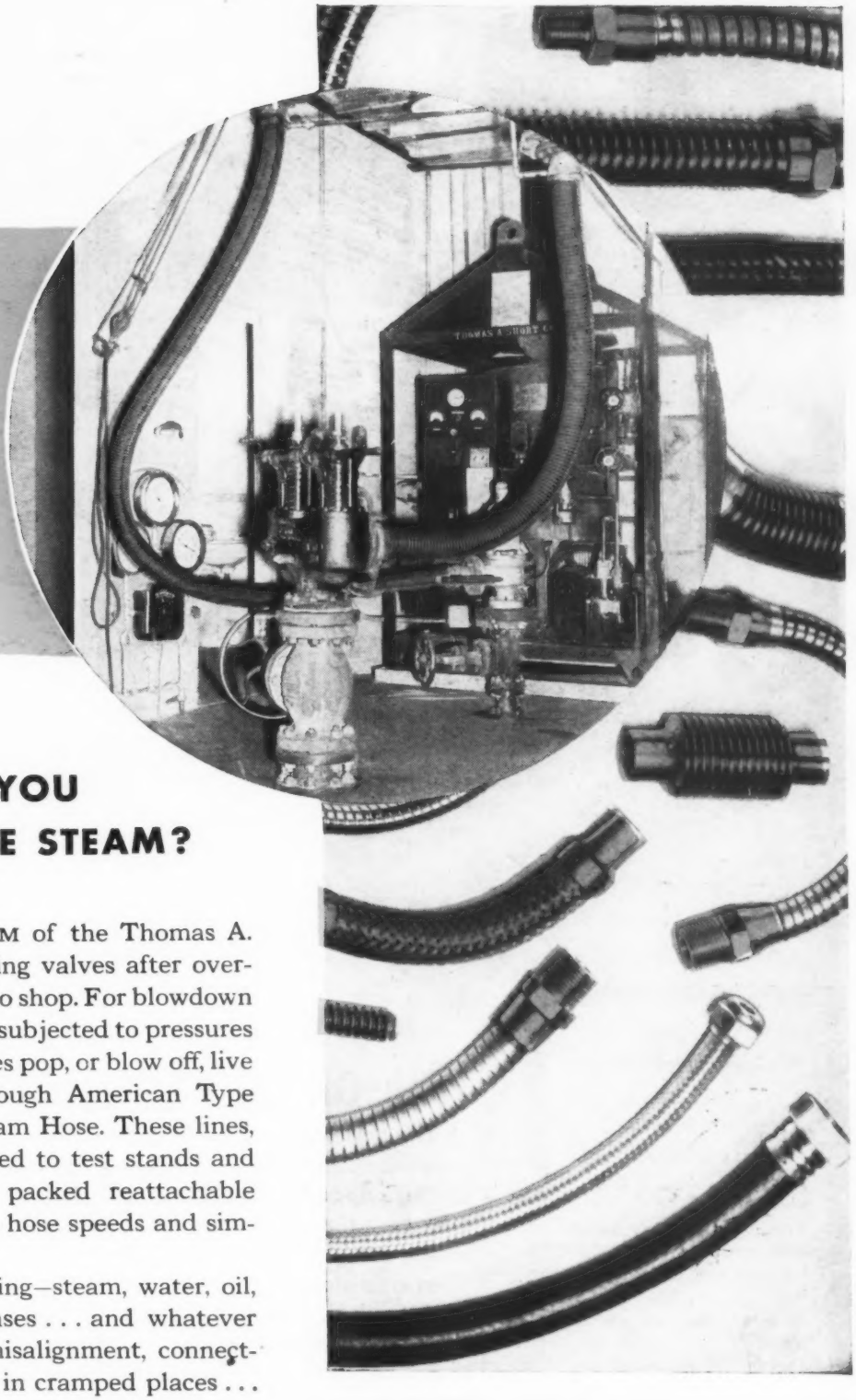
When these valves POP



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from mine to consumer

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THE CANADIAN-FAIRBANKS MORSE COMPANY, LIMITED

IMPROVE EFFICIENCY

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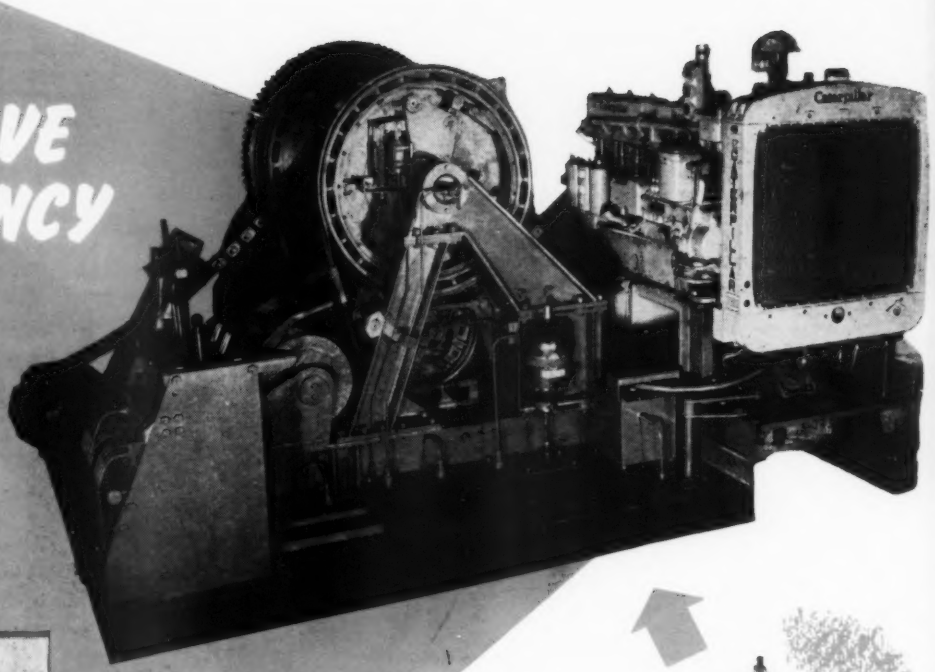

Photographs courtesy of
Link-Belt Speeder Corporation
Chicago, Ill.

CAPACITY:
From 2 cubic inches to 10 gals.

PRESSURE:
Up to 3000 psi

TYPICAL APPLICATIONS:

As a storage chamber & shock absorber.

As an emergency source of fluid power.

For operating secondary systems.

As a dispenser of oils or greases.

As a thermal expansion compensator.

To reduce size of power unit in intermittent duty cycles.

With GREER HYDRAULIC ACCUMULATORS

The series 300 Link-Belt Speeder Shovel illustrated here is a highly versatile machine featuring great speed, high mobility and large lifting capacity. And for peak efficiency and low-cost performance Link-Belt made certain that a Greer Accumulator was included as a major component of the hydraulic system.

In addition to providing smooth, shock-free operation the accumulator helps the machine to operate with uninterrupted stamina, strength, and reliability throughout the working day.

If your process or machine is hydraulically powered, investigate today how you too can profit by the use of a Greer Accumulator. The coupon below is for your convenience.

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HIGH-CARBON STRIP
COLD-ROLLED SPRING STEEL

REDUCES THE COST
IMPROVES THE PRODUCT

Due to the consistent uniformity of Weirton high-carbon strip cold-rolled spring steel, cold forming or blanking is easier. It has met requirements for a variety of products where high fatigue-resistance is a principal factor.

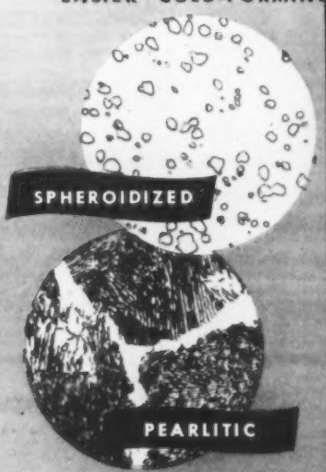
Where forming is required, Weirton supplies spheroidized-annealed cold-rolled spring steel to insure customers simple, economical fabrication. The controlled grain structure provides exceptional ductility for such a high carbon steel. Close technical control during manufacture insures those precise qualities you expect in a spring steel.

Where clean, economical blanking is required, Weirton supplies a product which is temper rolled to produce controlled ranges of hardness and tensile strength. The desired ranges are designed to meet the specific requirements of the customer's tool practice.

Weirton cold-rolled spring steel responds accurately to heat treatment after forming or blanking, has rigidly controlled chemical and physical properties, exact constancy of grain structure and controlled limits of decarburization. It has exceptional uniformity of gauge and width.

It is supplied with the desired chemical analysis and for specified heat treating and hardness ranges in strips up to 7 inches wide. Ask Weirton metallurgists to work with you in determining the correct specifications for your application.

SPHEROIDIZED FOR EASIER COLD-FORMING



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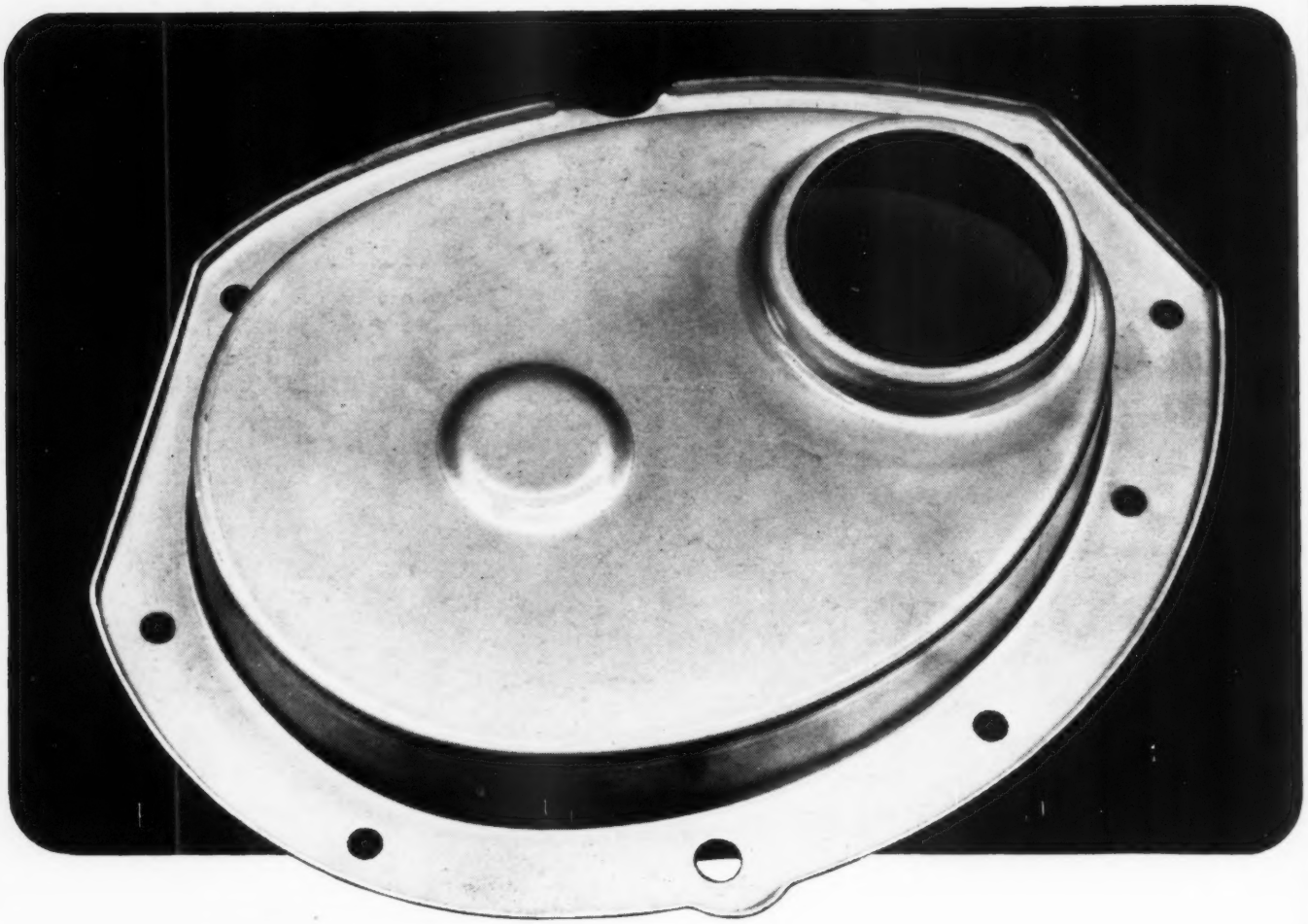
WEIRTON, W. VA. • *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION**

Executive Offices, Pittsburgh, Pa.



Experience...

Expertly designed and well constructed tools are essential to the production of trouble-free stampings. Parts of intricate shape, with irregular contours and varying depths of draw — and requiring precision tolerances — are a challenge to our craftsmanship.

Designed by our engineers, our tools are constructed by men practising their inherited skill which has been developed through long years of training and experience.

Presteel carries on constant research, seeking new developments which can be utilized in the design, construction, and final operation of tools, resulting in more economical production of quality stampings. Consult your nearest Presteel representative or write us direct about your problems.

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THE ELECTRIC AUTO-LITE COMPANY

Bay Manufacturing Division

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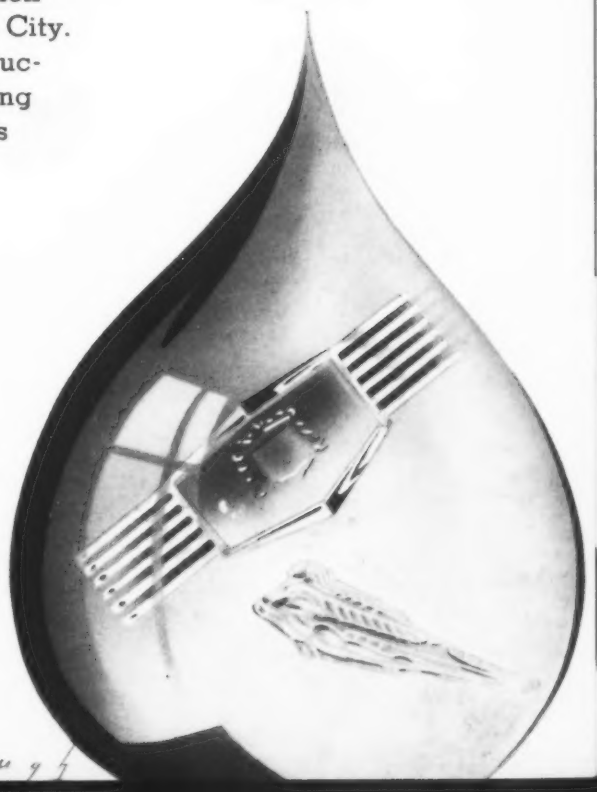


Auto-Lite

plastics and metals

AUTO-LITE MEANS PRECISION MANUFACTURING

Tune in "Suspense!", the Auto-Lite Radio Show—Thursdays, 9:00 P.M., E. S. T. on CBS.

Radabaugh

NEW *Life-Line* MOTORS NOW AVAILABLE

WESTINGHOUSE NOW OFFERS *IMMEDIATE DELIVERY* ON *STANDARD* LIFE-LINE MOTORS . . . IN RATINGS FOR 60% OF INDUSTRY'S REQUIREMENTS

To meet industry's urgent need for more—and better—motors, Westinghouse embarked two years ago on the biggest engineering and manufacturing program ever undertaken in this field.

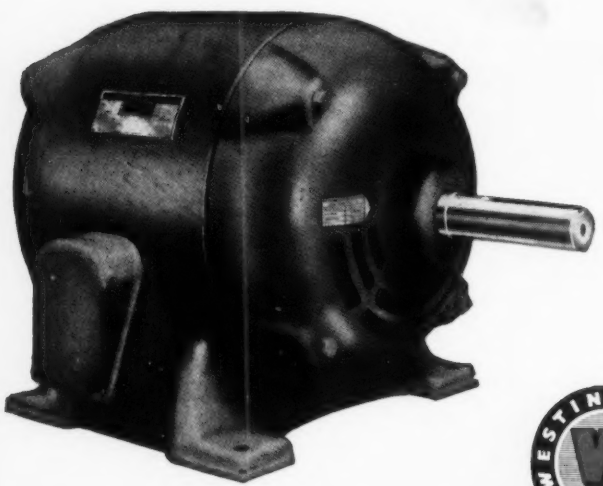
Industrial buyers were surveyed to find the improvements most desired in existing standard motors. These improvements were incorporated, for the first time, in a single motor—the Life-Line—*a motor designed, from scratch, to user specifications.*

To build the Life-Line motor, a complete new plant was purchased, tooled and equipped from the ground up, with machines and new techniques never used before to manufacture motors.

Today, we announce the attainment of our first objective. The new Life-Line motor is now available from stock, in standard types from 1 to 15 hp.

This objective was selected as of first importance, since 60% of standard, integral horsepower motors required by industrial users fall in this classification. Motor types included in stock are described on the opposite page. On "near-standard" motors, also described, short deliveries are available in these sizes.

Improved deliveries on special types and larger ratings will be the subject of future announcements, as quickly as increased output makes them possible. Watch for them . . . phone your orders to your nearest Westinghouse representative. Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. J-21497



Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Life-Line motors

FROM 1 to 15 HP* FROM STOCK

WHAT IS MEANT BY "STANDARD" MOTORS

"Standard" motors include drip-proof, splash-proof, totally-enclosed, fan-cooled and some totally-enclosed, non-ventilated complete motors, ball-bearing type, having standard electrical characteristics (220/440 volt, 2 or 3-phase, 50 or 60-cycle, standard speed torque and time-temperature characteristics).

Available from stock in ratings indicated below. Very short delivery on any standard non-stock rating in these frame sizes.

TYPES INCLUDED AS "NEAR-STANDARD" MOTORS

"Near-standard" motors are those with minor modifications, which include such items as double shaft extensions, NEMA standard B and C flanges, special No. 1 insulation, round frame, conduit box opposite standard, squeeze connectors instead of conduit box, TENV motors, partial motors, 50-cycle, 40° C. rise open motors, etc.

Short delivery in frame sizes listed below.

Life-Line A-C, Single-Phase, 60-Cycle, 110-220-Volt, Heavy-Duty Type CAP Capacitor-Start, Induction-Run Motors

HP	RPM	FRAME	VOLTS	IN STOCK
1	1750	203	220	✓
1½	1750	204	220	

Life-Line A-C, 3-Phase, 60-Cycle, Squirrel-Cage Motors

HP	RPM	F...		ENCLOSURE TYPES IN STOCK

*REMEMBER?

This announcement was published last spring—And now...

STOCK to 6 WEEKS Delivery

ON STANDARD 20 TO 75 HP MOTORS 445 FRAME AND SMALLER

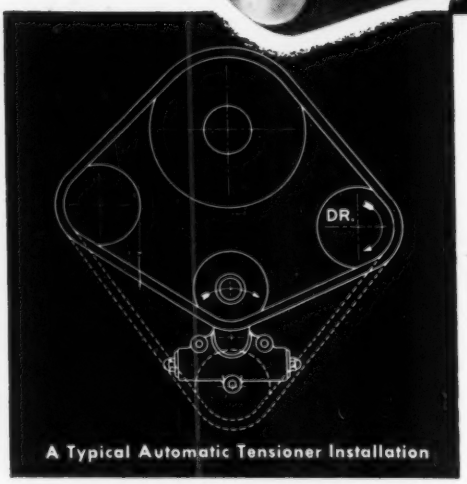
Here's good news for motor users. Westinghouse squirrel-cage motors . . . open or splashproof, NEMA designs B and C, frames 364 through 445 . . . can now be obtained in 6 weeks *or less.* Many are in stock. Even the larger sizes, up to 200-300 hp, now have reduced shipping schedules—the shortest since 1942.

Your local Westinghouse representative will give you specific information on the motors you need . . . in answer to your phone call.

NEW! Whitney AUTOMATIC TENSIONER

Increases Efficiency of all Types of Drives

ROLLER CHAIN, SILENT CHAIN OR BELT



A Typical Automatic Tensioner Installation

Now you can keep your power transmission drives delivering full efficiency with the Whitney Automatic Tensioner. Simple and easy to install, this tensioner automatically provides continuous take-up that compensates for drive wear. It also replaces special motor mounting tensioners on chain or belt drives.

Here's how it operates—a sprocket, roller or pulley, depending on the drive, is installed on the crank arm bearing surface, where it rotates freely. The continuous and uniform spring pressure of the Whitney Tensioner reduces whipping by maintaining the proper tension against the drive, eliminating slack at all times.

Regardless of the type of your drives, you can get and maintain peak performance with the Whitney Automatic Tensioner. Write for details and bulletin, today.

CHECK THESE ADVANTAGES

1. Positive action take-up, simple in construction with few wearing parts, adaptable to chain, belt, or other drive applications.
2. Flat base, three bolt installation. Allows position or location to be easily changed if desired.
3. Continuous spring pressure with only slight variation. Spring pressure easily adjustable.
4. Crank arm action can be either clockwise or counterclockwise, by reversing pinion rack and spring assembly body.
5. Sprocket or pulley on crank arm can be designed with ball or roller or needle bearing mounting.

WHITNEY CHAIN & MFG. CO.

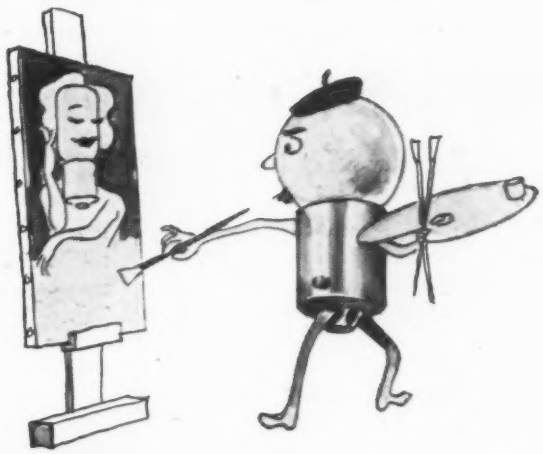
A Division of Whitney-Hanson Industries Inc.

204 Hamilton Street, Hartford 2, Conn.

These little lamps mean extra sales features for your product!

Want extra safety and convenience?

To indicate whether the current is on or off . . . whether the temperature is too high or too low . . . use a General Electric miniature glow lamp! Little safety and convenience features like these can make a big difference in sales for your product.



Want new sales appeal?

Small lamps behind colored plastics, or used as parts of a smart design, can bring a new, modern note of beauty to many products. Decorative possibilities are endless. G-E miniature lamps give you an opportunity to make your product unusual and distinctive, so that it stands out from all the rest.

Want novelty that brings the crowds?

There's nothing like novelty to catch a buyer's eye! And nothing like light to win attention! Little lamps can make your product more appealing—provide just that touch of difference that means quick sales. Many successful products have been built around G-E miniature lamps.

GENERAL ELECTRIC'S complete range of miniature lamps includes all types and sizes. Hundreds of tests insure high quality and dependable service. And G-E lamp specialists will gladly help you select the right bulb for your product. Always insist on this mark of quality . . . . . .

FREE BOOKLET

Contains more than 80 exciting design ideas that may suggest new possibilities for your product. Ask your nearby G-E Lamp Office for your copy of "Big Jobs for Small Bulbs." Or write General Electric, Dept. 166-PE-12, Nela Park, Cleveland 12, Ohio.

Whatever lamps you need, G-E makes 'em all!

G-E LAMPS

GENERAL ELECTRIC

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. "Bridgeport" BRASS CO. *Headquarters for BRASS, BRONZE and COPPER*

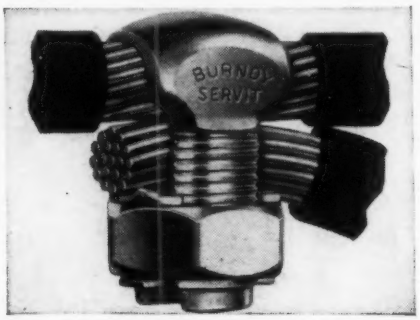
Silicon Bronzes, Aluminum Bronzes
For Severe Engineering Requirements

Engineers are recognizing more and more that shutdowns due to corrosion of small but important parts can be avoided by using non-rusting, high-strength metals.

This explains the trend toward a wider use of Silicon Bronzes and Aluminum Bronzes for pole line hardware, marine hardware, building hardware and other articles that are subjected to moisture and weathering. Pole line hardware – bolts, nuts, wire, cable connectors, etc. – gives metals their most difficult assignment, since it is widely used for carrying high tension power lines and must be absolutely dependable.

Silicon Bronze Connectors Can Be Used Repeatedly

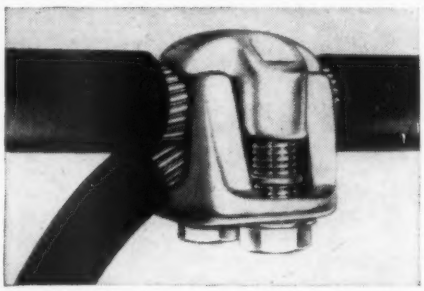
For ease and speed of assembly, and to permit repeated use, connectors are generally designed on the principle of clamping conductors with threaded devices rather than soldered joints. Because they are meant to be re-used time after time, these labor-saving connectors must not deteriorate under the severest service conditions.



Burndy Servit, a split-bolt type electric service connector, is made from Bridgeport Aluminum Bronze 715. Courtesy Burndy Engineering Co.

These exacting requirements explain why the Silicon Bronzes and, more recently, the Aluminum Silicon Bronzes, are used for fastening and connecting devices, whether they suspend high voltage lines hundreds of feet above the ground, or tie in the electrical arteries of a building.

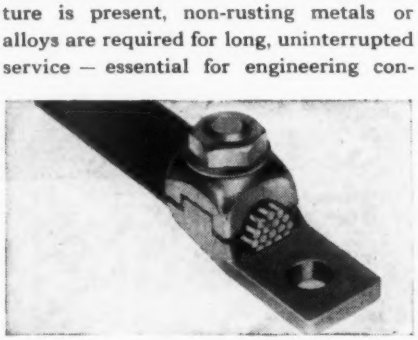
Bridgeport Silicon Bronze 609, for example, is widely used for the manufacture of high strength bolts and nuts. Hard drawn Silicon Bronze wire retains its malleability to a surprising degree. Consequently, it work-hardens rapidly, without developing brittleness. Bolts can be economically made by cold heading and roll threading with no intermediate anneals. The strength of the material is fully developed in the finished bolts, which average about 100,000 psi in tensile strength. This high value is remarkable, inasmuch as this alloy contains about 98% Copper and 2% Silicon. Compare this exceptionally high strength with that of ordinary steel bolts, which average about 70,000 psi in tensile strength when new, i.e., before they begin to rust. Silicon Bronze resembles Copper in corrosion resistance, developing a green surface patina which retards further corrosion.



Burndy Oklip Connector, designed for heavy-duty service. Body made from Duronze III* (Silicon Aluminum Bronze); bolts from Bridgeport Silicon Bronze 609. Courtesy Burndy Engineering Co.

Reduce Maintenance and Replacement

There are many other engineering uses besides the applications mentioned, where Silicon Bronzes and Aluminum Bronzes should be specified. In fact, where moisture is present, non-rusting metals or alloys are required for long, uninterrupted service – essential for engineering construction where both high strength and corrosion-resistance are factors. A wider use of these alloys will do much to reduce the cost of corrosion that amounts to many millions of dollars every year in repairs, shutdowns and eventual replacements.



Burndy Qiklug, a lug or terminal for general use. Bridgeport's Silicon Bronze 609 is used for the nut because of its high strength. Courtesy Burndy Engineering Co.

*Reg. U. S. Pat. Off.

Brass Through The Ages

The fine enduring properties of brass, bronze and copper have ever been linked with the religious symbols of worship of countless peoples in many lands. Artists and craftsmen have always enjoyed working with these metals because of their attractive colors, easy workability and their enduring qualities.

Today's altar sets, consisting of crosses, candle holders and chalices, produced by Rostand Manufacturing Company, established 1902, are still made with much skilled hand labor. However, most brass and copper items are made by mass production methods involving long runs and special equipment and tools.

Graceful shapes are obtained by spinning rather than by drawing and stamping. Pedestals, for example, are the result of assembling parts made from flat brass strip by numerous brazing operations.

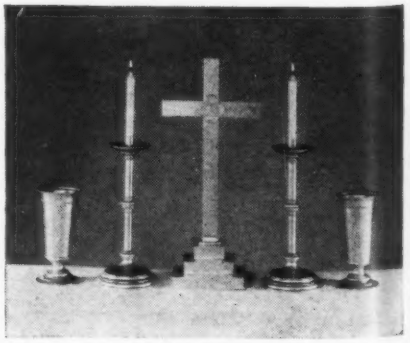
The finished parts are carefully polished to bring out the warm color of the brass, which is then lacquered to preserve its lustre. With articles that are handled often, the finish is retained by using gold plate. More emphasis is placed on the quality of fine workmanship than on low prices.

Studies of the most ancient and primitive ruins indicate that the metallurgy of copper and its alloys was practised in its crudest forms in the earliest periods of man's development. Evidences of prehistoric metallurgy have been found in western Europe and Egypt in the "smelters hoards" of the Bronze Age. There are many references to brass in the Bible which, due to faulty translation, may have been either bronze or copper. The Mycenaean, Phoenician, Babylonian and Assyrian civilizations, stretching over the period from 1500 to 500 B. C., also yielded many copper and bronze objects.

Even as late as 1574 brass was made by mixing calamine, fine coal, alum, salt and copper in granules or small fragments, then heating for many hours to form brass.

Strip brass for buttons was made in Waterbury, Connecticut, early in 1800.

Today the purest of copper and zinc are melted together in huge electric furnaces. Mechanical equipment is necessary to handle the cast bars which weigh up to 2,000 lbs. each.



Altar sets of exquisite design and fine workmanship are made from brass and involve many hand operations. Courtesy Rostand Manufacturing Company, Milford, Connecticut.

CAUSES OF CORROSION

This article is one of a series of discussions by C. L. Bulow, Research Chemist of the Bridgeport Brass Company.

GALVANIC CORROSION IN SALT WATER

Satisfactory Galvanic Couples

The extremes in potential differences between various copper-base alloys in sea water and in 3% sodium chloride solutions is small, seldom exceeding 0.2 volts. Consequently copper and various copper alloys can be successfully coupled together in such corrosive media. This explains why they are so widely used in salt water services.

The potential difference between dissimilar metals may be unimportant due to the smallness of the exposed area of the more noble member of the galvanic couple. For example, copper alloy bolts fastened in steel plates immersed in sea water do not necessarily lead to increased corrosion of the steel. In such a galvanic couple, the *initial* potential difference between copper and low carbon steel may range from 0.5 to 0.7 volts. This lack of activity is due to stifling of the cathodic reaction on the relatively small surface of the copper alloy bolt head and nut. The stifling is due primarily to deposition of magnesium and calcium carbonate from the sea water on the cathodic surface (copper alloy). This explains why the widespread use of bronze bolts to fasten steel or cast iron parts in marine services has led to no difficulty from galvanic corrosion.

Zinc coatings on steel, such as are produced by galvanizing, give considerable galvanic protection to the underlying steel. This protection usually continues until practically all of the zinc has corroded.

Where steel or aluminum is coupled to relatively large areas of painted copper so that the copper surface cannot function as a cathode, little or no accelerated corrosion of the steel or aluminum occurs. However, "it is the safest practice to paint both the anodic and cathodic areas with the best alkali-resistant paints available.

(Continued from column 1)

Care should be exercised to avoid pinholes, uncoated edges, fraying surfaces and similar foci for galvanic attack".[1]

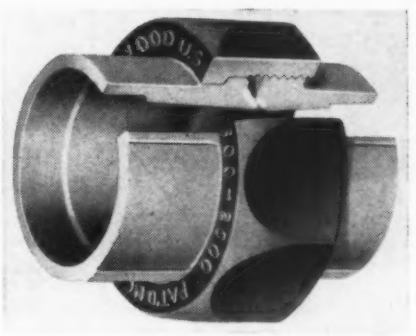
[1] G. W. Segren, G. H. Young and F. L. LaQue, Corrosion (N.A.C.E.) 2,2, 67-77 (1946).

Silicon Bronze 632 Eliminates Corrosion at Seat Joint of Rockwood Sprinkler Unions

The Rockwood Sprinkler Company Union shown below has seats made from Bridgeport's Silicon Bronze 632 for extra strength, toughness and resistance against corrosion. These cold-forged steel unions are meeting all general piping requirements in the shipbuilding, chemical, steel, rubber, paper, textile and allied industries.

Silicon Bronze 632 contains approximately 97% copper and 3% silicon. In applications similar to this union seat joint, the high strength of silicon bronze is advantageous and its joining properties are at least equal to phosphor bronze.

Stronger, tougher and more fatigue resisting than copper, it also offers excellent resistance to season or corrosion cracking and fine cold working qualities for operations such as bending and flaring. It is recommended where specifications call for higher physical properties than can be met with copper.



Seating foils of Silicon Bronze 632 in new modern socket-weld union manufactured by Rockwood Sprinkler Co.

NEW DEVELOPMENTS

This column lists items manufactured or developed by many different sources. None of these items has been tested or is endorsed by the Bridgeport Brass Company. We will gladly refer readers to the manufacturer or other sources for further information.

Reversing Blade in new screwdriver makes it possible to drive standard and Phillips head screws with same tool simply by a quick reversal of blade. **No. 892**

Wire Straightener is announced that straightens length of heavy wire for pass through feed tube rolls and supplies power to push wire into nut formers and other cold heading equipment. **No. 893**

Metalworking Tool Kit is said to provide handy assortment of tools for shop or on-the-job sheet metal work. Included are radius cutter, heavy-duty straight line cutter, metal shrinker and metal stretcher. **No. 894**

New Type Grinding Wheel consists of inflated rubber wheel that carries abrasive band to provide a resilient tool for finishing flat or curved surfaces and depressions. **No. 895**

A Staging Fixture is reported to speed positioning of threaded work on optical projection comparators, holding it in correct position to check pitch diameter, major and minor diameters, crest, flank angle and lead in any ANF screw between .073" and 1.0" O.D. **No. 896**

New Refractory Material is said to provide thermal barrier simply by applying by brush, trowel or extruding gun to such surfaces as electrical junction boxes, heat-exchanger couplings, steam pipes, hot air ducts, etc. **No. 897**

Machinability Testing Fixture is said to weigh the vertical pressure component of a machining cut made by a standard-sized carbide-tipped bit secured in the holder. A dial gage shows deflection due to load in terms of machinability of material being cut. **No. 898**

A New Gear Gage has been announced that is made with 20-degree pressure angle full length tooth forms and stub tooth forms. It is said that by merely rolling the gage over the teeth of a gear the pitch can be determined without error. **No. 899**

An Improved Blue-Color Layout Fluid has been developed, which is said to be suited for application to brass, copper, stainless steel, cast iron and tin surfaces to provide a background through which layout lines can be scribed. **No. 900**

BRASS, BRONZE, COPPER, DURONZE, NICKEL SILVER, CUPRO NICKEL

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STRIP AND SHEET — For drawing, stamping, forming, spinning. Leaded alloys for machining, drilling, tapping. Silicon bronze, phosphor bronze for corrosion resistance. Alloys suitable for springs. Engravers' copper and brass.

WIRE — Cold Heading alloys for screws, bolts, nuts, nails, fastenings, electrical connectors, Phono-Electric trolley and contact wires.

ROD — Alloys for screw machine operation. Duronze III high strength, corrosion-resistant, good for machining and hot forging. Hot forging and cold heading alloys. Welding Rods. Copper-covered ground rod.

TUBING — For miscellaneous fabrication. For condensers and heat exchangers. For water, air, oil and hydraulic lines.

DUPLEX TUBING—For conditions too severe for a single metal or alloy.

PIPE—Brass and copper for plumbing.

FABRICATED GOODS — Plumbing brass goods. Radiator air valves. Aer-a-sol insecticide dispensers. Automobile tire valves.

TECHNICAL SERVICE — Staff of experienced, laboratory-trained men available to help customers with their metal problems.

WAREHOUSE SERVICE — Warehouse and jobbers stocks available for prompt delivery in principal cities.

TECHNICAL LITERATURE — Manuals and handbooks available for most products.

"Bridgeport" BRASS

BRIDGEPORT BRASS

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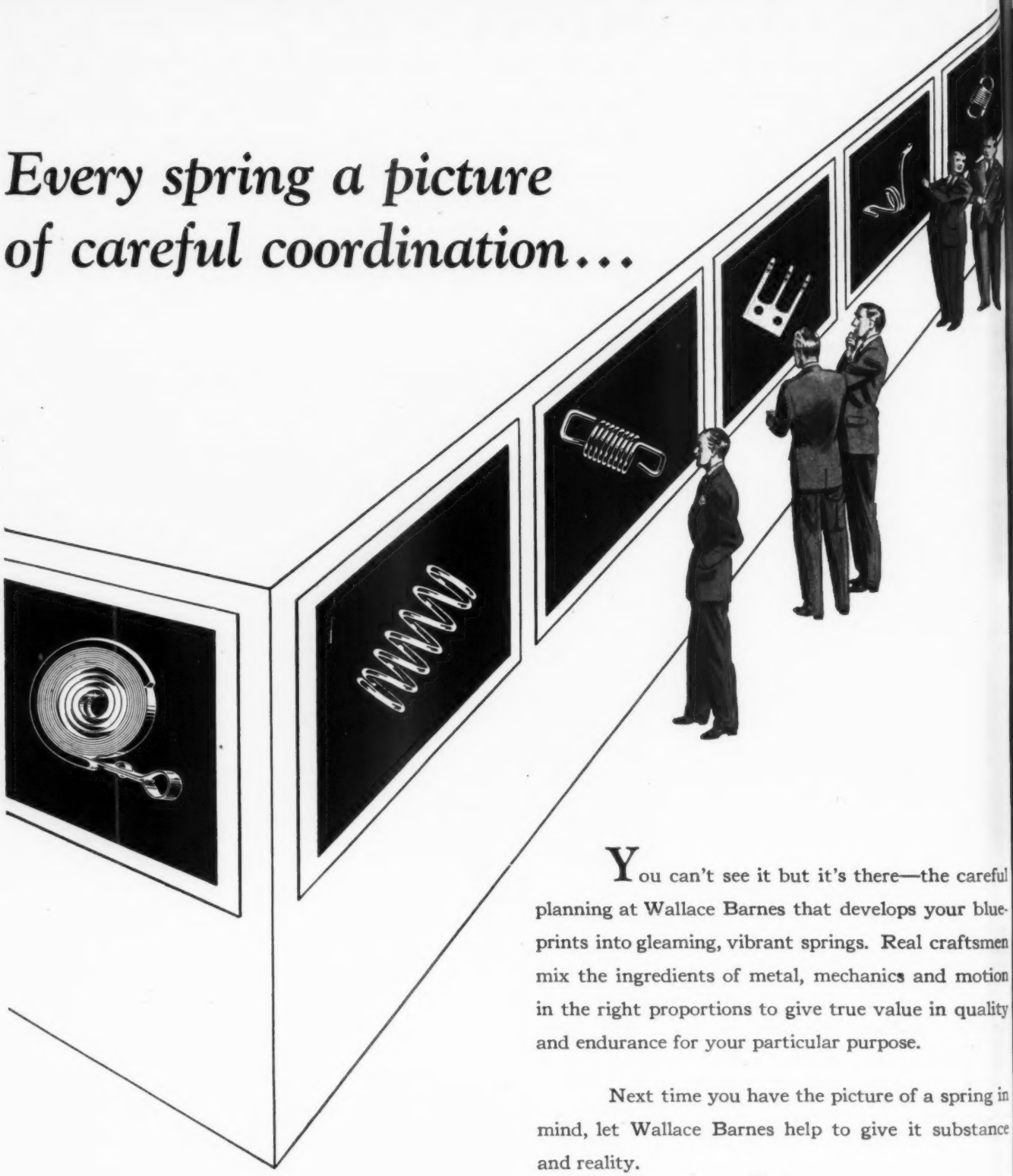
Every spring a picture of careful coordination...



You can't see it but it's there—the careful planning at Wallace Barnes that develops your blueprints into gleaming, vibrant springs. Real craftsmen mix the ingredients of metal, mechanics and motion in the right proportions to give true value in quality and endurance for your particular purpose.

Next time you have the picture of a spring in mind, let Wallace Barnes help to give it substance and reality.

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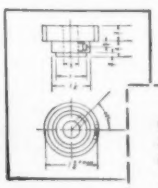

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She's dividing the plus and the minus

Here's one way the "quiet" is built into a Federal Ball Bearing...in the *selective assembly* of balls and race-rings of matching dimensions.

Federal-manufactured balls are uniformly spherical within .000025″... never vary more than .00005″ in any one bearing. The ball track is ground to a chatter-free finish and just the right radius. And only precisely gauged balls and race-rings of similar plus-or-minus dimensions are combined.

After all tolerances and dimensions are checked, Federal Ball Bearings are tested for quiet running, smoothness, parallelism and fit. That's why, when you need a power-saving bearing that permits heavier load margins at higher speeds, "Federals" are equipped to carry out your specifications.

Over one hundred production, inspection and *cleaning operations*, with *every fourth operator an inspector*, provide the assurance that there's friction-free, long-lasting performance in *every* Federal Ball Bearing.

Your application may benefit from a Federal Ball Bearing installation. Our representative in your vicinity will be glad to call and discuss it with you. Why not call him in now? Or write for our catalog "K." It describes the full range of Federal Ball Bearings.

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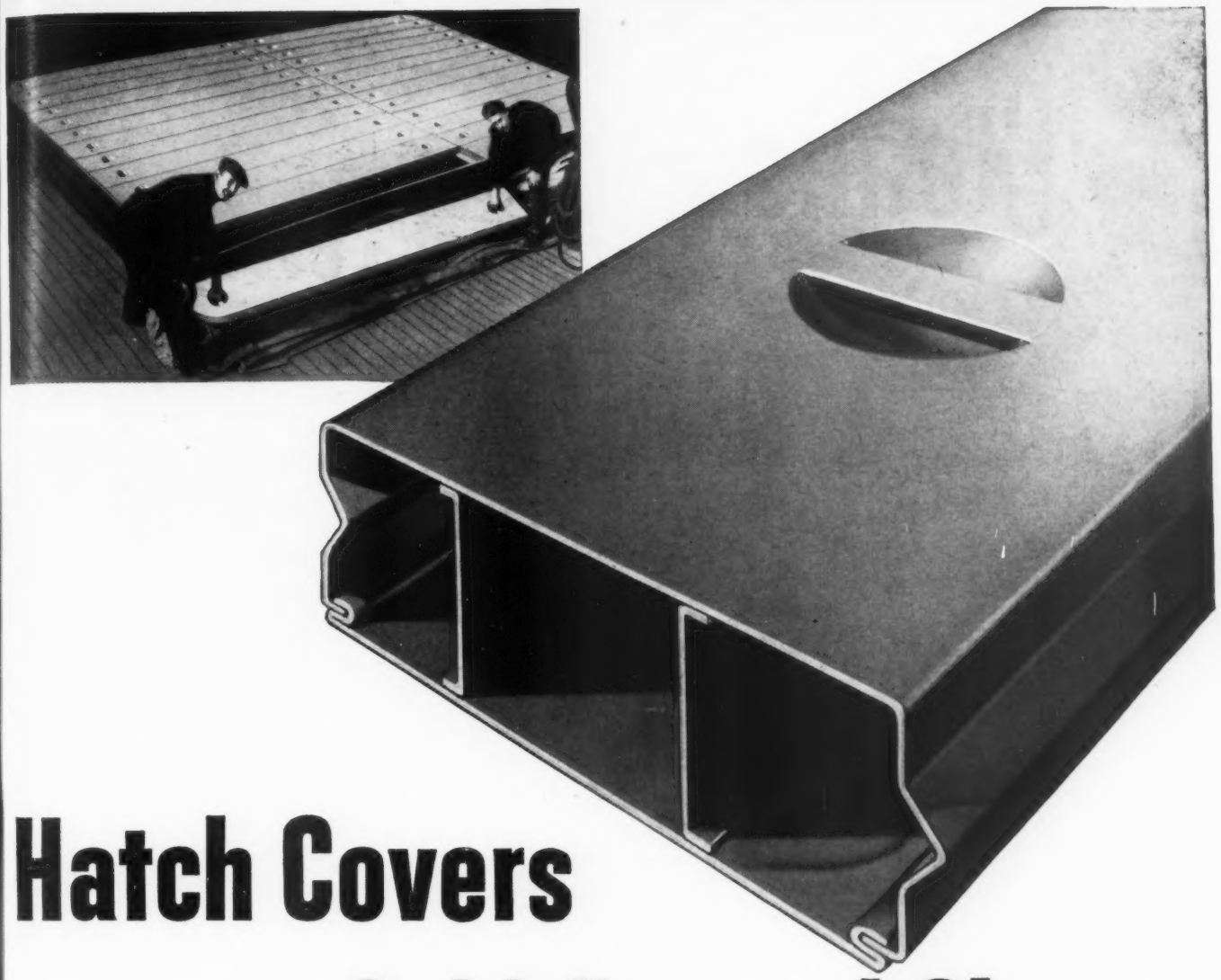
ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS



Hatch Covers MADE FROM Cold-Formed Shapes

This water-tight hatch-cover section, used by leading steamship operators, is made from Bethlehem Cold-Formed Shapes. It is manufactured in widths of 12 in., in varying depths, and in lengths to meet all hatch beam arrangements for unsupported spans up to 10 ft. The section is reinforced internally with two longitudinal channel stiffeners, and is packed with approved marine insulation for added protection against fire.

Sections for hatch covers are but one of a long line of products which are being made today, either wholly or in part, from Bethlehem Cold-Formed Shapes. And in many types of industry new uses are continually being discovered for these economical, easy-to-use shapes.

Bethlehem Cold-Formed Shapes are produced from strip, sheets or plates. They are uniform in thickness, and have an excellent strength-weight ratio. Their surface is virtually scale-free. They're made in all gauges from 7 to 24, inclusive. Because of our complete manufacturing facilities we are able to meet practically every requirement.

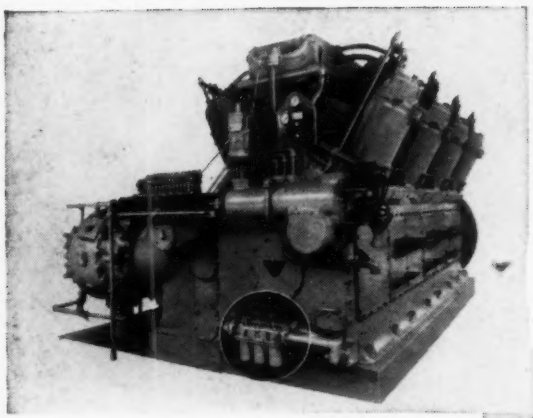
There may be places where Bethlehem Cold-Formed Shapes could be used to your advantage in some of your products. Why not talk it over with us?

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

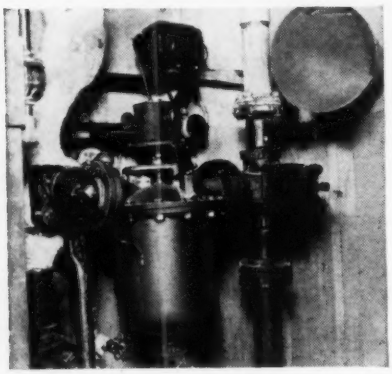
On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

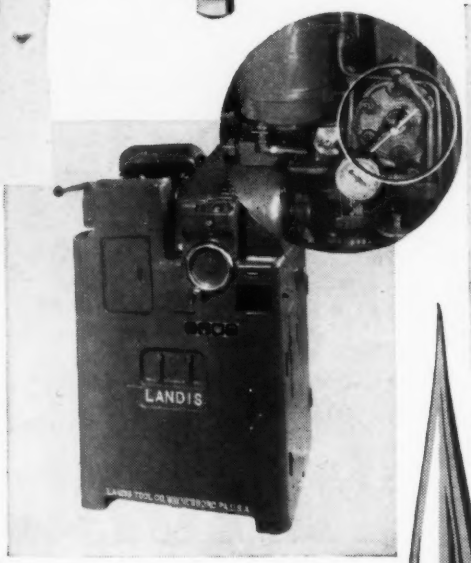
Cleans every drop ...without stop



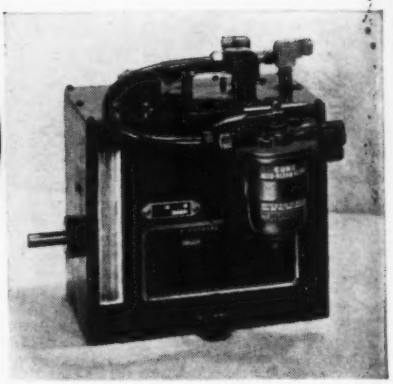
CONTINUOUS CLEANING is why this Diesel manufacturer selected Cuno Auto-Klean Filters as standard equipment. Externally-mounted all-metal filters are cleaned—without stopping flow—by periodic turning of handle.



AUTOMATIC FILTER CLEANING by motor drive is used in this installation where soap is filtered at 300 lb per minute by Cuno Auto-Klean, an application where pressure loss must be minimum.



COMPACTNESS of Cuno Auto-Klean appealed to designers of this high-speed grinder. Built-in cartridge handles full flow of hydraulic system in same space as usual partial-flow type.



POSITIVE REMOVAL not only of metal chips, fine dust, and powder but also of water, from lubricating oil, protects printing presses, special machinery, etc., serviced by this Automatic Lubricator.

Send Coupon

FOR FREE INFORMATION ON *CONTINUOUS CLEANING*

Cuno Engineering Corporation
301 South Vine St., Meriden, Conn.

Please send information—without obligation—on Cuno continuous cleaning for application checked.

- ☐ Lubricating Oil
- ☐ Hydraulic Oil
- ☐ Fuel Oil
- ☐ Water
- ☐ Coolants
- ☐ Industrial Fluids
- ☐ Coatings and Finishes
- ☐ Process Liquids
- ☐ Food Products

Name.....Title.....

Company.....

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PLEASE ATTACH COUPON TO YOUR EUSINESS LETTERHEAD

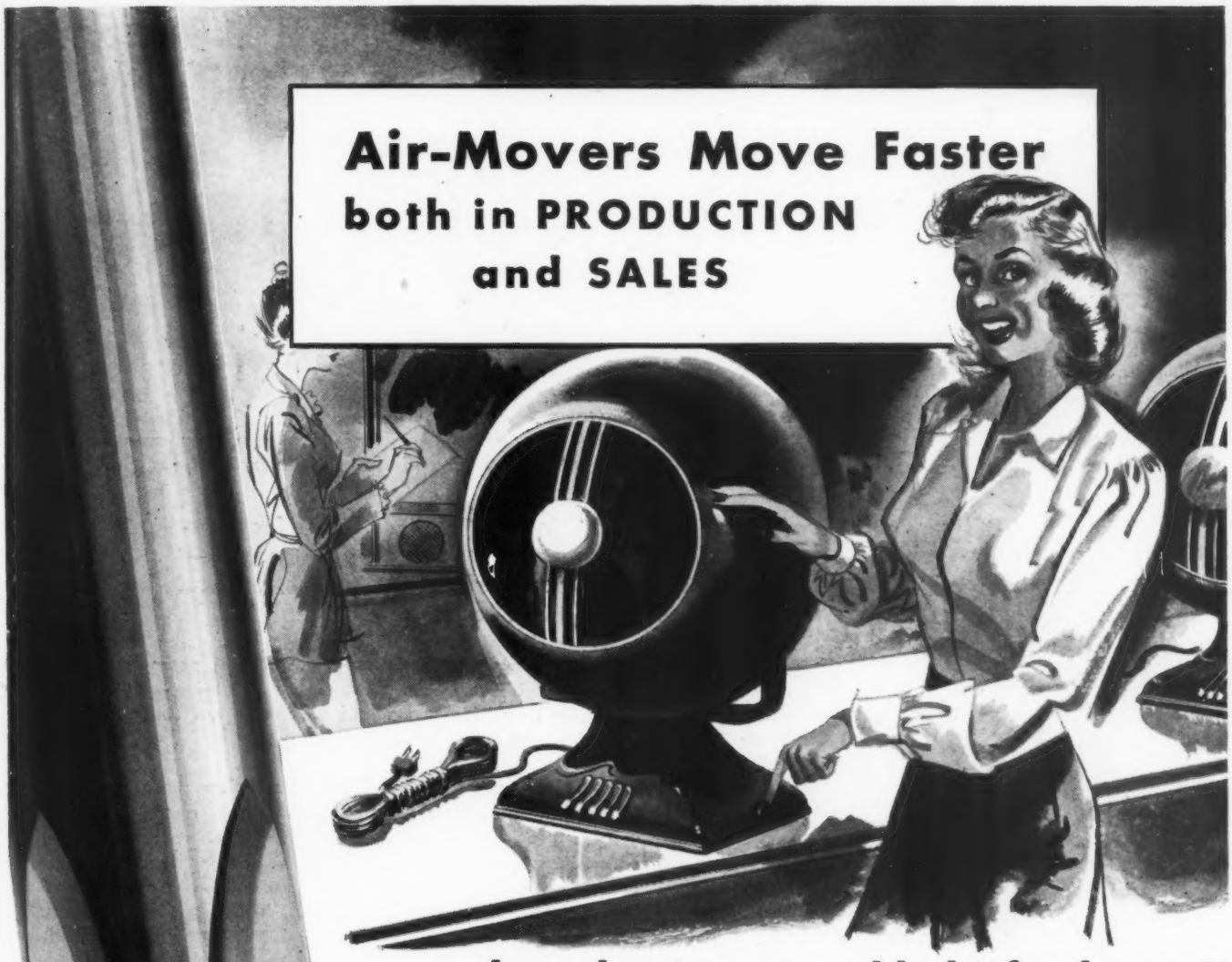
CUNO

Fluid Conditioning

REMOVES MORE SIZES OF SOLIDS FROM MORE TYPES OF FLUIDS

Micronic • Disc-type • Wire-wound • Fabric Filters

Air-Movers Move Faster
both in PRODUCTION and SALES



. . . when they're assembled "for keeps" with AMERICAN PHILLIPS SCREWS

"FAIR WINDS" IN PRODUCTION: These new "wind-tunnel" fans are designed for lasting efficiency, exceptionally handsome appearance, and unbroken silence in operation. So what other fastening method could be used—*except* American Phillips Screws? Now there's no danger of damage to the deep-drawn, sleek surfaces, no burring of screwheads, no lagging production due to fumbled and slant-driven screws. In fact, assembly moves 50% faster than it does with slotted screws.

"FAIR WINDS" IN SALES: Good-looking modern design of American Phillips' universal cross-recess is a definite accent to the modern design of any product in which these screws are used. And salesmen can accent the story of extra vibration-resistance—which protects silent operation and prolongs product-life. See what American Phillips Screws can do for your product, both in production and sales. Write.

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

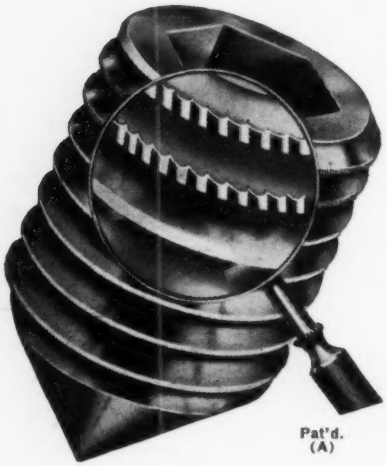
Chicago 11: 589 E. Illinois St. *Detroit 2:* 502 Stephenson Building

AMERICAN PHILLIPS *Screws*

ALL TYPES

ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

speed PRODUCTION! *with...*



Pat'd. (A)

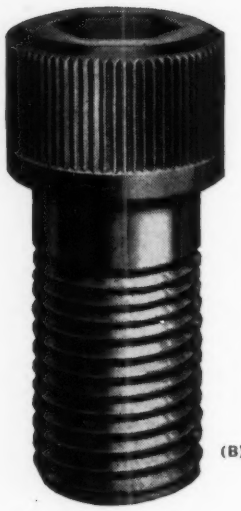
UNBRAKO

Reg. U. S. Pat. Off.

Knurled

SOCKET SCREW PRODUCTS

Millions of these "Unbrako" Socket Screw Products—in sizes from No. 4 to 1½" diameter, in a full range of lengths—are being used throughout industry to: **save assembly time, facilitate compact designs, reduce weight and costs.**



(B)

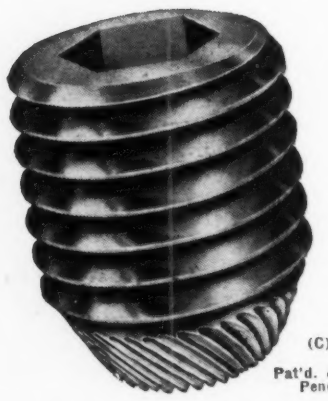
(A) The KNURLING—as shown—swages the threads of this patented "Unbrako" Socket Set Screw,—so that it becomes a most excellent Self-Locker . . . for use with—cone, flat, oval, half and full dog points, which can not be knurled—a Set Screw that positively "will not shake loose"!

(B) The head of this ubiquitous "Unbrako" Socket Head Cap Screw is KNURLED to speed assembly. The KNURLS "gear" right to the fingers, no matter how oily, and a positive slip-proof grip is the result—no waste motion. Of course, the Internal Wrenching feature provides cost savings in material, weight and space.

(C) The patented KNURLED cup point of this popular "Unbrako" Socket Set Screw makes it a Self-Locker . . . because the sharpened edges of the counter-clock-wise KNURLS positively prevent creep, regardless of the most chattering vibration. A real fastener, if ever there was one . . . positively **will not shake loose!**

As all our patented "Unbrako" Set Screws, regardless of point, are Self-Locking, we can lock most any set screw application. We are prepared to furnish "Unbrako" Socket Screw Products in Stainless Steel.

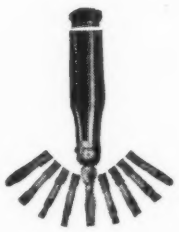
Write us for the name and address of your nearest "Unbrako" Industrial Distributor and your copy of the "Unbrako" Catalog.



(C)

Pat'd. & Pats. Pending

Knurling of Socket Screws originated with "Unbrako" in 1934.



Kits. Pats. Pend.

You can't tighten or loosen socket screws without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex-socket bits.

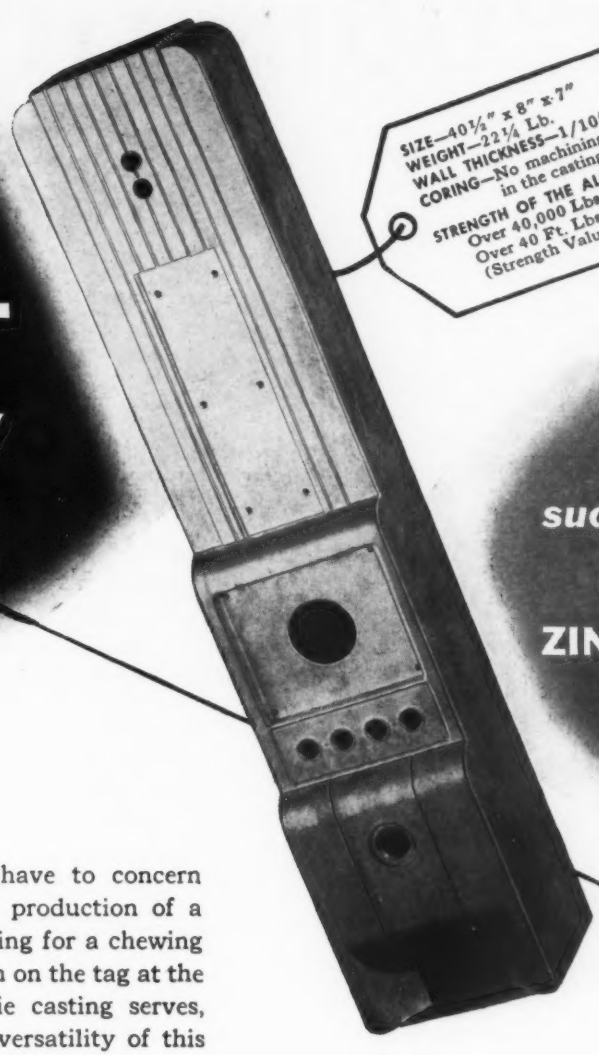
OVER 45 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNSYLVANIA BOX 545

BRANCHES: CHICAGO DETROIT INDIANAPOLIS ST. LOUIS SAN FRANCISCO

a husky housing- *smartly* styled


SIZE—40½" x 8" x 7"
WEIGHT—22¼ Lb.
WALL THICKNESS—1/10" av.—sides and face
CORING—No machining—all openings cored in the casting operation
STRENGTH OF THE ALLOY—
Over 40,000 Lbs./Sq. In. Tensile
Over 40 Ft. Lbs. Impact—¼" Bar
(Strength Values Determined on Test Bars)

another successful product designed for ZINC DIE CASTING

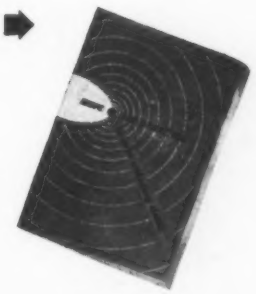
You will probably never have to concern yourself with the design or production of a casting as large as this housing for a chewing gum vendor (the size is given on the tag at the top). This unusual zinc die casting serves, however, to emphasize the versatility of this metal and method of production.

The problem was to produce a housing which would meet the requirements of size and strength and still offer an attractive appearance to stimulate the sale of chewing gum. The dimensions and physical characteristics on the tag above, coupled with the obviously smart styling, could not be achieved—in a one-piece design and at comparable cost—by any other fabrication process. The smooth as-cast surfaces of the housing are easily finished with a gleaming red enamel.

This vendor is just one of many successful products designed for zinc die casting in the field of business machines. Typical applications in other major industries will be covered in future advertisements in these pages.

SEND FOR THIS BOOKLET ➡

A new booklet—just off the press—has 64 pages of photographs depicting zinc die castings in the assembly of a wide variety of products in many fields. Send for your copy today!



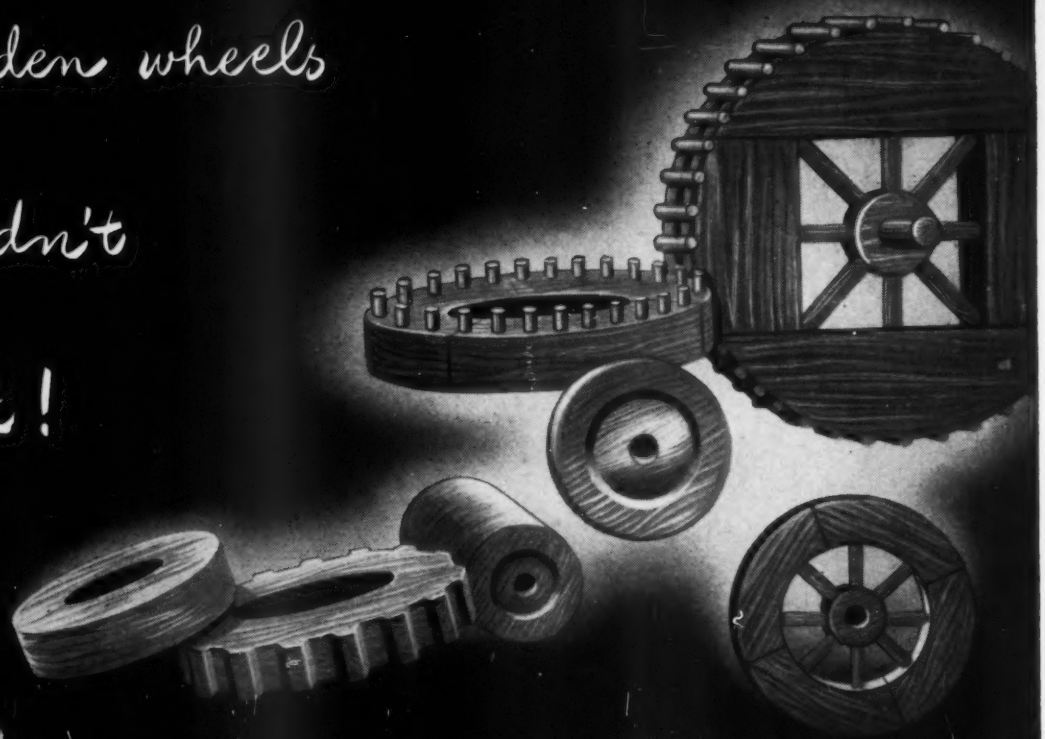
ZINC
FOR DIE CASTING ALLOYS

THE NEW JERSEY ZINC COMPANY, 160 Front St., New York 7, N. Y.

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

Wooden wheels wouldn't work!



Time was, wooden wheels were the rule—but would *you* use them today, in your product?

HOLD ON—MAYBE YOU ARE USING THEM!

Look at it this way. Suppose some of your components could be made cheaper and better by a different method or material. Aren't they the same as "wooden wheels"?

That new and better way may be *die casting*. We know of many, many cases where manufacturers could replace machined parts, stampings, sand or plastic moldings with die cast parts. The savings would startle you!

Why not go over your production methods with a fine-tooth comb and see where Gerity die castings might solve problems and save money for you? Our engineers will be glad to help you or your engineers in every way possible.

AMERICAN DIE CASTING INSTITUTE · DCI · MEMBER

Gerity-Michigan
CORPORATION
Adrian, Michigan

THESE FLANGES

Answer Important Questions About

Which Stainless Tubing To Use...

Here is another example of the results you can get when you put Carpenter's experience with Stainless Tubing to work in your plant.

These Van Stone flanges were done cold, with the flanges rolled-out from the tube wall. Expansion is uniform throughout the flanged area. The corner at the back of each flange is sharp—with no weakening of the metal's structure.

When you are selecting Stainless Tubing and planning your fabrication jobs, it will pay you to make full use of Carpenter's experience. Want proof? Drop us a line, and we will work with your engineering staff.

SLIDE CHART DATA ON STAINLESS TUBING

This Carpenter Stainless Tubing Slide Chart provides information that has never before been available in such easy-to-use form. It contains data on Velocity Constants, Mass Velocity Constants, Areas of Tube, Physical Properties, etc. For your copy, just send us a note on your company letterhead.

THE CARPENTER STEEL COMPANY

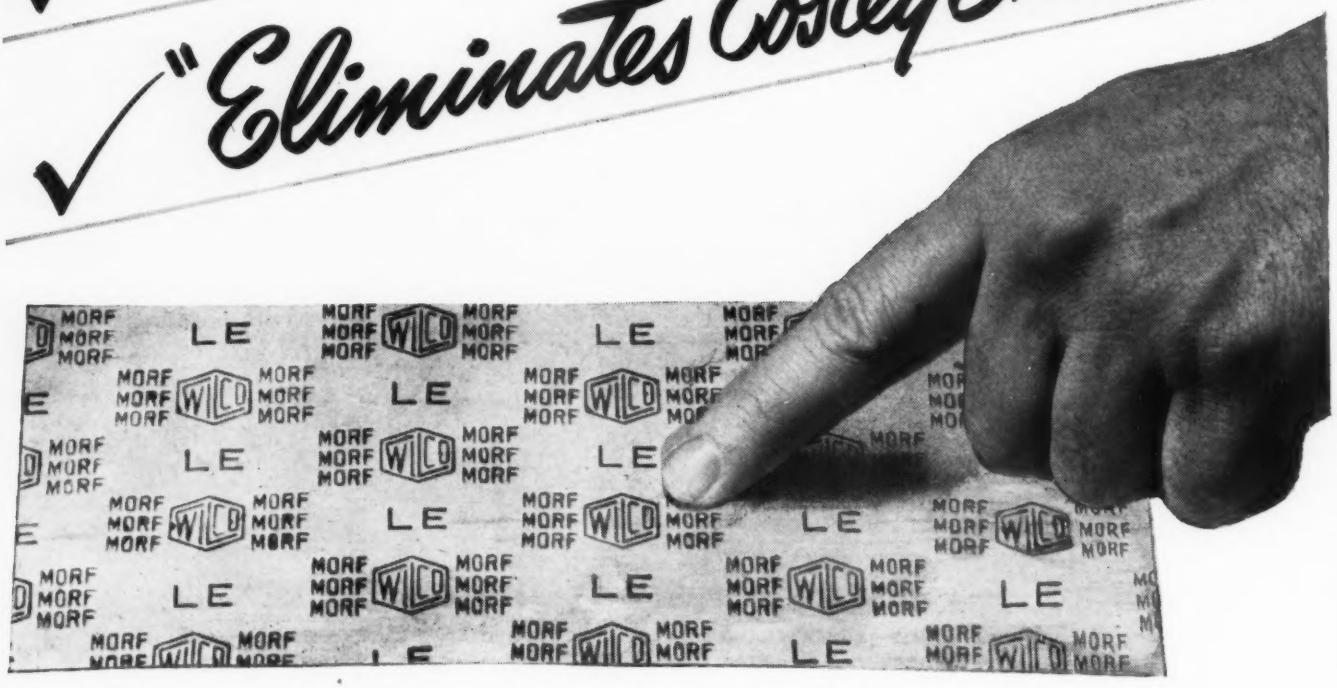
Alloy Tube Division **• 121 Springfield Road, Union, N. J.**

Carpenter

STAINLESS TUBING

"MORE THAN CORROSION RESISTANCE"

✓"Instant Identification"
✓"Eliminates Costly Errors"



. . . that's what manufacturing customers say about the new WILCO method of positive BIMETAL IDENTIFICATION.

The new Wilco method of bimetal identification is meeting with a wide and favorable response from industry. Users of Wilco Thermometal find the clearly etched pattern on every strip avoids confusion between the low-and high-expanding sides and readily identifies each Wilco type.

This etched pattern on the low-expanding side instantly identifies the bimetal and precludes any possibility of costly errors. In the above illustration, for example, the abbreviation, "MORF," stands for Wilco Morflex. The letters, "LE," are a reminder that the etched side is low-expanding. By carrying this clear-cut method of identification throughout the entire line of 30 Wilco Thermometals, all possibility of confusing one type with another is eliminated.

Each strip also carries the famous WILCO trademark, your assurance that it is a product of The H. A. Wilson Company, pioneer in the field of thermostatic bimetal.

Another example of practical Wilco pioneering

The H. A. Wilson Company is an American pioneer in the design and development of thermostatic bimetal. For 34 years, WILCO has supplied American industry with these materials as sheet or strip, in partly or completely fabricated Thermometals and as parts of assemblies for thousands of applications. The 30 WILCO Thermometals are adaptable to all temperature ranges, deflection rates and electrical resistivities.

WILCO engineers—specialists in the *precision production* of thermostatic bimetals—will gladly cooperate with you in securing the most effective use of WILCO products.

THE H. A. WILSON COMPANY
105 CHESTNUT STREET, NEWARK 5, NEW JERSEY
Branch Offices: Chicago, Detroit, Los Angeles, Providence

WILCO

SPECIALISTS FOR 34 YEARS IN THE MANUFACTURE OF THERMOMETALS - ELECTRICAL CONTACTS - PRECIOUS METAL BIMETALLIC PRODUCTS AND SPECIAL ALLOYS

Designs Based on Surveys

FOR MANY YEARS RESEARCHERS and pollsters have been deluging the public with written or oral questions concerning their likes and dislikes about automobiles. According to sales propaganda and the claims of market researchers, designers faithfully followed the expressed wishes of the motorists and thus was created the modern car that fits the needs and tastes of the motoring public perfectly. Does it?

Elsewhere in this number of PRODUCT ENGINEERING is a letter by Mr. George Cawley, consulting engineer of Upper Montclair, N. J. In his letter, Mr. Cawley reviews numerous absurdities in the design of the modern motor car. A few of his criticisms are mentioned in this editorial, but his letter should be read to get the full impact of the deficiencies in present auto models.

Of course, Mr. and Mrs. Motorist asked for a low "functionally streamlined" car. But, had they been asked if they wanted to have their hats taken off when getting in or out of their car, the answer undoubtedly would have been an emphatic no! A positive affirmative was the answer to the pollsters' question, "Would you like a wider front seat and wider rear seat?" But if the question had been, "Would you like the fenders flush with the sides of the car so that they will be scratched and dented most easily?", the answer would undoubtedly have been different.

To get the most effective streamlining such as requested, according to surveys, of course the roof had to be tapered downward over the rear seat. The question asked should have been, "Do you like to ride in the rear seat without your hat on?" The length of rear overhang had to be increased to give further "functional streamlining," which of course added trunk space. Both features presumably received a big vote. But if the motorist had been asked if he liked to bump parking meters, trees, or telegraph poles, or find the average parking space too cramped to get into, or finally if he desired to own a car that is too long for his garage, the answer probably would have been different.

Numerous additional absurdities in the design of the modern automobile are referred to in Mr. Cawley's letter. Blinding reflections from chrome plated parts and glass surfaces, the excessive sloping of the windshield which makes the wiper ineffective, the inaccessibility of certain engine parts, the almost impossibility of attaching skid chains, and the higher dollar cost of repairing the slightest bump are only a few of the many proper criticisms mentioned. But why even mention them? The motoring public asked for such features according to the pollsters.

Well, with all deference to political polls, Truman was elected.

G. F. Zodenkoff

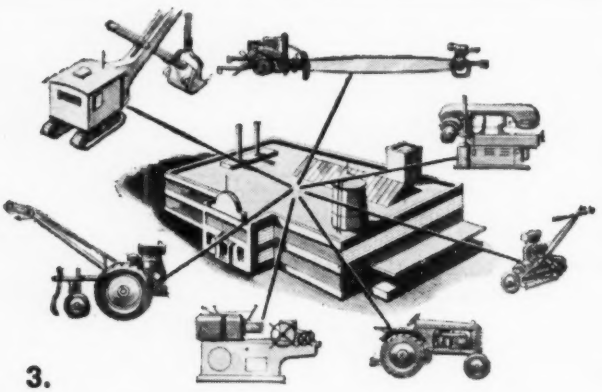
Let Morse grease the rails for your tough jobs too!

1.

Sc-r-r-ee-ch! Railroad men know this noise means that expensive train wheels and rails are wearing away on curves. To prevent this wear, automatic greasers were installed to lubricate wheels and rails. Old-style ratchet type clutches were tried, but slipped or didn't feed grease right. American Brake Shoe Company's Ramapo Ajax Division solved this knotty problem . . .

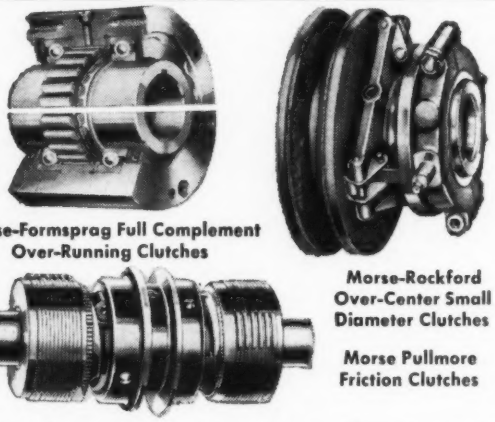
2.

They now use Morse-Formsprag Clutches. The positive action of Morse-Formsprag Clutches is far superior in performance, dependability and service over the old ratchet type. *M-F Clutches engage instantly; allow no back-slip; feed grease to every passing wheel.* Other complex operations on your products may call for Morse-Rockford Friction Clutches . . .



3.

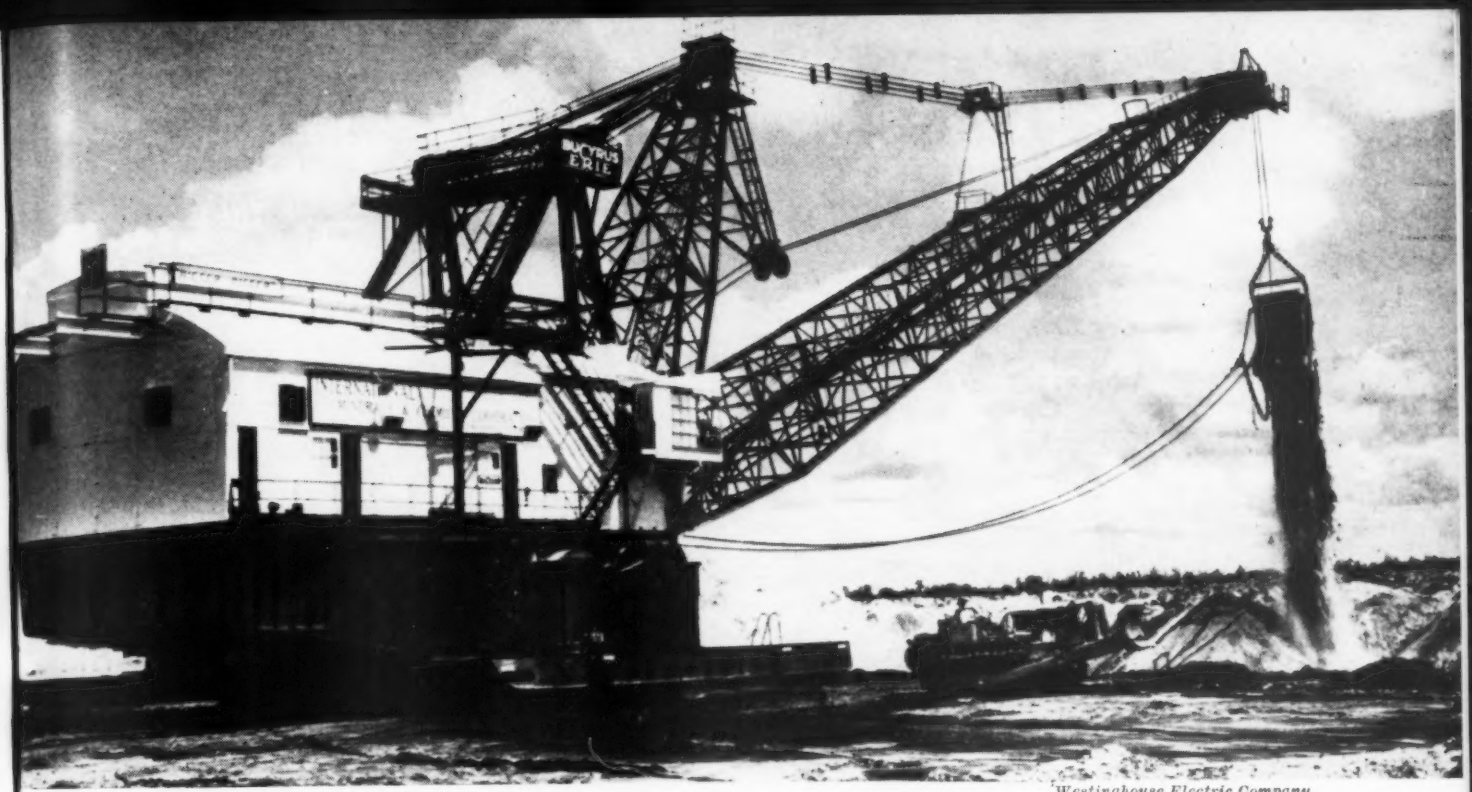
Morse clutches fill almost every need you can imagine. Can the sales and mechanical value of your own products be enhanced by using Morse clutches? Leading manufacturers of such items as construction equipment, cultivators, saws, pumps, lawn mowers and machine tools have bettered *their* products with Morse clutches. How about you? Do this now . . .


Morse-Formsprag Full Complement Over-Running Clutches
Morse-Rockford Over-Center Small Diameter Clutches
Morse Pullmore Friction Clutches

4.

Write for expert clutch engineering aid and consultation. For new ideas, send for clutch catalogs: Morse Formsprag Clutch Catalog, No. C11-48; Morse Pullmore Clutch Catalog, C31-47; Morse-Rockford Clutch Catalog, SDOC. Address: Morse Chain Company, Department 258, 7601 Central Avenue, Detroit 8, Michigan.

MORSE CHAIN COMPANY • DETROIT 8, MICHIGAN



Westinghouse Electric Company

A REGULATING GENERATOR improves the performance of this shovel. The cycle time to swing the shovel to the spoil bank and return is reduced about 20 percent as compared to the conventional three-field generators and contractor control.

Why Consider An Adjustable Speed Drive

Economic, production and design variables that require machine speed to be changed to get optimum output from the equipment.

TODAY management welcomes the opportunity to buy a machine that can pay for itself in a year or two, but there is only a slim market for the production machines that can't quickly recover their cost. Those same high wages that have placed a big premium on refinements in machinery have correspondingly increased the dollar value of a higher rate of machine productivity. This economic dilemma presents a great opportunity for machine designers to increase the salability of their product by enabling the buyer to get the most out of the machine.

There are many ways of increasing the rate of production of a machine, but the simplest and most obvious method is to make the machine run faster. Most machines are furnished the customer to run at a given fixed speed which the designer has selected as being the fastest speed that can be used for the slowest operation. Essentially, the designer has told the customer that it is just too bad about the other operations on which the machine conceivably might run faster. He realizes, but may fail to appreciate the significance of the fact that he is limited by the restrictions of many possible operations, but the customer is limited only by the restrictions of his particular set-up.

Usually some factor will enable the customer to increase speed profitably.

Because the terms "adjustable speed" and "variable speed" are used rather loosely, they are briefly defined here. If the number of speeds that can be selected is unlimited (within a certain range), then the speed is said to be "adjustable" or more correctly, "infinitely adjustable." This is sometimes called "variable speed," but to many engineers "variable speed" implies a speed that fluctuates under load. This article will use "adjustable speed" as meaning that the drive can be readily controlled to give any speed desired, within a given range, as selected by the operator.

Frequently the customer changes a belt or gear drive to increase speed; unfortunately, he still has a constant speed machine. He may have to rebuild the drive entirely to enable speed control through the medium of an adjustable speed transmission, or an adjustable speed motor. Why wasn't the machine so equipped in the first place? The answer is simple.

In almost every machine, optimum running speed is not a fixed quantity, but a variable that is affected by many factors. Consider a simple punch press normally furnished with a fixed speed motor. This speed has to be sufficiently slow to handle a cupping operation. Suppose that the machine is bought by a user who wants to stamp washers. For this buyer, the machine is not particularly efficient because it won't run at maximum production speed for his job. He will probably change the gears so as to step up production. Then, perhaps his engineers develop an automatic feeding device for the press. Now the press is again too slow, and

new gearing is required to realize the utmost from the machine. Perhaps air blast ejection is added. Again the machine speed must be stepped up, or the customer wastes production potential. Along comes a new development in tooling, such as tungsten carbide. Overnight machine's optimum speed jumps to a new high. The machine now has an obsolete drive. After new gearing or a new motor is applied again, the punch press is back in operation at a new high rate of production. Suddenly a new model, a change in design, or new production scheduling requires that a different part be made in this machine. As was bound to happen, this part is cupped. The user now must delay production while he changes the speed of this machine to meet the requirement of a slower operation. Pity the poor customer! He has been handicapped and harassed because the designer failed to give him a machine capable of meeting likely operating conditions.

This analysis is not as far fetched as some might believe. Examples can be cited where one manufacturer stepped up the production rate of punch presses from 75 pieces per min to better than 800 pieces per minute.

The lesson to be learned is this: The user will not be able to obtain maximum production out of a machine at all times and for all jobs unless the speed can be changed conveniently to the optimum speed for the particular job at hand.

The range of speed adjustment required to meet all conditions may be 2 to 1, 8 to 1, or even as high as 120 to 1, depending upon the particular machine under consideration. The means for adjusting speed may be mechanical, electrical, electronic, mechanical-hydraulic or mechanical-electrical. Each has its place.

To analyze the speed problem, it is necessary to list all the possible factors that might influence the optimum speed of operation. Undoubtedly, one cannot foresee every condition that might require a change of speed. However, the factors group themselves under these main divisions:

1. Variations in the part being produced.
2. Variations in the tooling.
3. Variations in ambient conditions.
4. Variations in the material during the processing.
5. Variations in the work load.

Benefits other than higher output accrue to the buyer. But, before considering subsidiary advantages, a thorough analysis of the ways in which an adjustable speed device for the main machine motor enables maximum production is worthwhile.

For maximum output, speed must be adjusted to meet variations in . . .

. . . The Part Processed

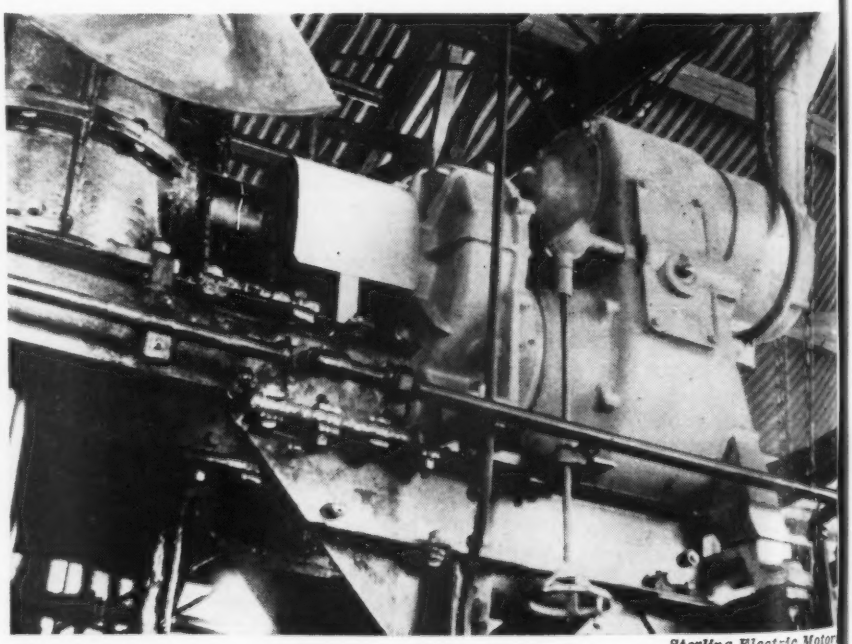
DIFFERENT PARTS are perhaps the most common variable that require speed adjustment for maximum output. For instance, the punch press might be set up to make lock washers, and later be shifted over to the manufacture of grease seals. Accordingly, the operation is changed from blanking to cupping, and machine speed will have to be changed for optimum performance. The same problem exists in almost every field of machinery. A dewatering press for removing the moisture from vegetable might be used to dewater fruit. A lathe turning out motor shafts might be shifted to the manufacture of end plates.

This need of machine versatility has so many applications that it is hard to conceive of a machine which will not be required to handle different kinds of parts during some time in its life. For a general purpose production tool, an adjustable speed drive is mandatory if the user is to get the most out of the machine.

MATERIALS are another variable that require a change in speed for maximum production. With the enormous number of alloys available in ferrous materials alone, a machine tool that does not have a means for changing speeds in many steps over a wide range is bound to be inefficient on many jobs. To the wealth of the ferrous materials available, add the light alloys, then consider the bewildering parade of new plastic materials. It can be seen that an adjustable speed drive for cutting, forming and virtually all other metal production machinery is mandatory if the user is to get the most out of the machine.

Variations in materials are common not only to the metal-working industry, but also must be met by printing presses which handle different kinds of paper, by textile machinery working with different yarns, in materials handling equipment, in chemical processing and a host of other machines running into the same basic problem.

SIZE variations are another reason why speed changes are required to maintain optimum production. Even though a given part is to be made of a given material, an intentional or unintentional variation in the thickness of the material may call for speed change. Suppose that 12-gage wire is unavailable for forming a certain spring, so that 10-gage wire must be substituted. Speed change may be required. A machine for squeezing the juice out of oranges, for instance, in a commercial cannery should be run as fast as possible without squeezing the bitter oils out of the rind and thus spoiling



Sterling Electric Motors

STEPLESS SPEED CONTROL of grease-compounding kettles, made possible by this speed adjusting device, saves as much as 2 hr a day over the old one speed drive. It also enables different types of grease, each requiring a different agitating speed, to be produced in the same kettle. Equipment required is thus minimized.

the juice. This maximum optimum speed varies with the size of the oranges. The only way to insure maximum production with acceptable quality is to use an adjustable speed drive.

PHYSICAL PROPERTIES may cause variation in machine performance and therefore require speed adjustment. In metal-working machinery, adjustable speed is particularly important because of the many variations in hardness, shear strength, machinability and heat-treatment. Punch presses, lathes, drills, milling machines, planers, grinders, broaches are affected by the variations.

Unit weight may be the variation that must be handled by adjusting the speed. A rubber extruder is typical. To control uniformity of product, speed must be constantly and accurately adjusted so that the weight per unit length is uniform. Similarly, to get the maximum out of a printing press, speed control is essential. Speed adjustments enable a press to handle a variety of paper stocks having different responses to the inking.

. . . The Tooling

DIFFERENT KINDS of tools are almost a certainty during the life of any machine. For instance, a shaper will have to use different kinds of cutters, a drill press will be used with different kinds of twists and a grinding machine will run wheels of different grits.

AUTOMATIC FEEDING devices generally establish a higher optimum operating speed. Such devices are not hard to develop and may be built by the user. Automatic controls, solenoids and positioning devices such as dial feeds are extending the applications of automatic feeding mechanisms. To take full advantage of their use, speeds must be adjusted.

AUTOMATIC EJECTION can be added to many machines to increase the rate. Punch presses are being equipped to air eject stampings clear of the dies. Vacuum actuation has been used to quickly release sheets of paper, labels and similar lightweight materials.

BETTER MATERIALS FOR TOOLS may be developed, and the designer should always keep in mind this possibility. The outstanding example in this field was the development of tungsten carbide tooling. Any machine tool that was unable to be adapted to the new cutting speed requirements became obsolete overnight. New abrasives, and new means for bonding abrasives have been developed for grinding wheels, enabling higher speeds. These and other tool materials enable substantial increases in output. The builder of machinery should not handicap his equipment by failure to provide a drive that can meet any situation.

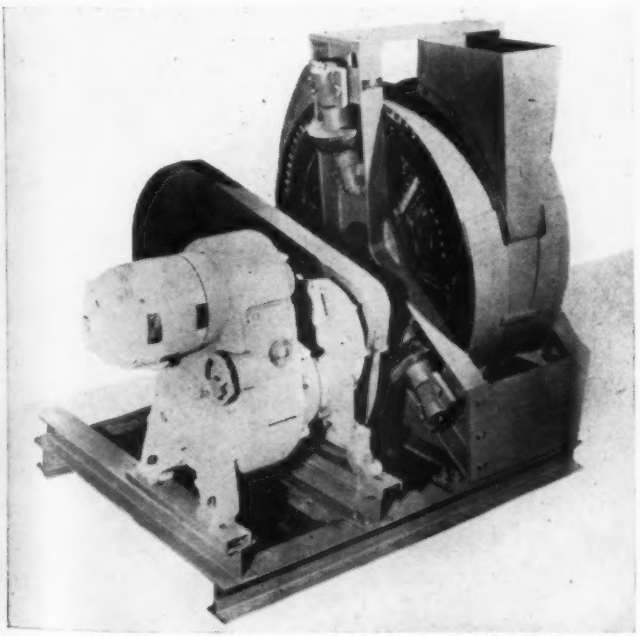
. . . Ambient Conditions

TEMPERATURE AND HUMIDITY VARIATIONS are particularly significant in the textile and paper industries. These variations also effect some of the chemical process industries. An example of the importance of meeting this variation is in textile slashers. Uniformly constant tension in the winding is the key to quality. Much damage to warped yarn is primarily the result of variations in tension which occur with changes in humidity. An adjustable speed drive is essential. In recent years electrical speed controls for slashers have gradually replaced mechanical devices because of the sensitiveness and accuracy with which tension can be regulated. Although these control systems are quite expensive, their increased productive capacity is worth it.

. . . Variations in Loading the Machine

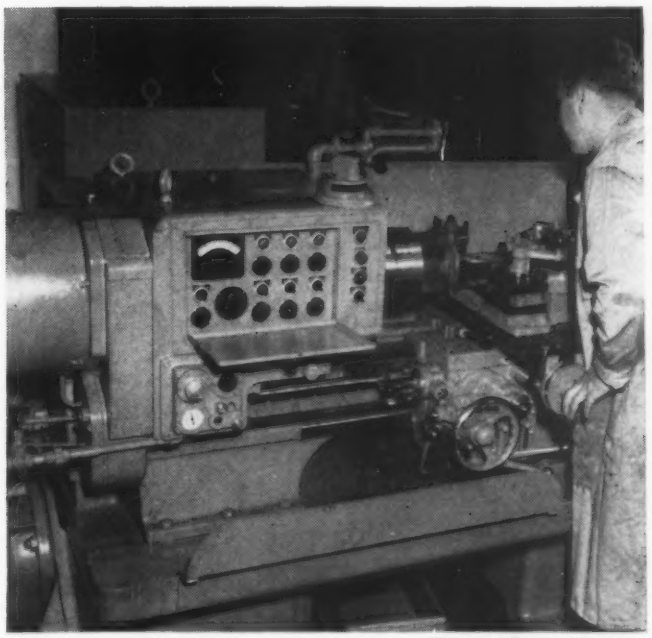
IN A CONTINUOUS PRODUCTION LINE, the machine's speed must be adjustable to meet the requirements of the entire line if it is to maintain the speed of the overall fabrication process. There might be times when the other machines are speeded to handle peak loads or slowed for repairs and inspection operations. An adjustable speed drive is needed to keep the line moving at maximum efficiency. A conveyor belt drive, for instance, usually ought to have speed adjustment to meet the needs of any production line in which it might be used.

SYNCHRONIZING is an important application for adjustable speed drive. Practically all types of strip mills and continuous strip production machines,



Sterling Electric Motors

WIDE VARIATION in type of food materials fed through these de-watering presses, and cycle speed changes, require operating speed to be changed. Optimum productivity is assured only by an adjustable speed device. Fifty percent increases have been made.



Warner & Swasey Company

ULTIMATE in speed control is the electronic system used on this turret lathe. Advantages: Increased productivity because best cutting speed can be selected quickly; increased versatility because any material can be accommodated; less operator fatigue.

Westinghouse Electric Corporation

PERMISSIBLE MAXIMUM LOAD is maintained by electronic control on this cylinder head milling machine which adjusts to provide uniform maximum cutting speed. Results: Maximum output, prolonged tool life, tool breakage prevented.

such as rubber, textile, paper, steel and wire-drawing mills, must have a means for synchronizing the speed so that processing will be at a uniform rate.

A CHANGE IN OPERATORS may make an adjustable speed device desirable. For instance, men and women may operate a machine interchangeably with a significant difference in speed. Or the operator's duties may be such that there should be a way of changing the speed to suit the individual. Adjustable speed drive may be valuable if it is desirable to pay a wage differential to the more rapid operator.

PLANT OPERATIONS affected by business conditions, seasonal factors, and such influxes of work for other reasons often vary the load on a machine. An adjustable speed drive will enable the machine to meet peak speed requirements. For instance, many kinds of machinery in fruit-packing houses have been equipped with adjustable speed drives so that the incoming flow of fruit can be regulated in proportion to the quality, and also to the number of packers working at that time. If the fruit is poor or extra dirty, the machinery can be slowed so that proper cleansing and packing can be done. At harvest times, output may be four times as great as during the slow season. This is an instance in which an incoming variable load is regulated so that the overall efficiency of the plant will be at a maximum.

THE KIND OF WORK coming through the plant may determine a need for speed change. For instance, a kiln ram hydraulically operated to move cars through pottery kilns has an optimum speed determined by the size of the load, the types of material, and the time required to obtain complete baking. A variation of speed up to 75 percent is required for optimum performance under any combination of these variables. Production was increased about 50 percent in one plant because an adjustable speed drive was added to take advantage of the minimum time requirements. Better quality also resulted from optimum timing.

AMOUNT OF WORK ON HAND for the particular machine sometimes affects optimum machine speeds. Pumps and other units in process industries, for instance, often require constant adjustment of speeds as determined by the amount of material available. Sewage pumps are often set to maintain a tank or flow bed at a specified level. And speed has to be varied with the inflow. This is done by an adjustable speed drive.

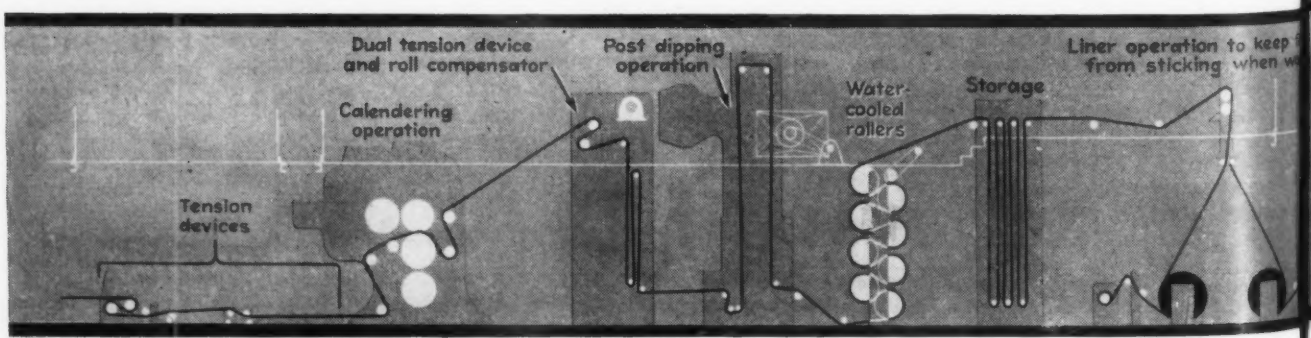
TO MAINTAIN MACHINE EFFICIENCY adjustable speed may be required. Perhaps the best example of this is the use of an adjustable speed drive on centrifugal pumps to control output. Although it is simple enough to throttle a pump, many designs are inefficient under throttling and the best way to reduce output yet maintain high efficiency is to use an adjustable speed drive.

. . . Variations During Processing

CHANGE IN SIZE during the operation is perhaps the most usual variable during processing. Material is removed by cutting tools, or size is increased as with a reel on which wire, paper or cloth is wound. Frequently rock crushers, conveyors and mixing machines require speed change during the process as the size or character of the product is modified.

TO MAINTAIN CONSTANT CUTTING SPEEDS as the surface is modified by the cutting action of the tool is not a luxury, but a necessity with machine tools. Tapers, spirals, reduced turning radii all must have a speed regulation device for maximum production.

TO MAINTAIN A CONSTANT LOAD is one of the newest refinements in the application of adjustable speed drive. Holding maximum load output has two purposes: first, the machine power is utilized to the utmost; and secondly, tool breakage can be prevented because



HIGH QUALITY and uniformity are achieved by the synchronized General Electric electronic drives of this calender train, combining

the cutting load is held at the maximum safe figure.

CHANGES IN VISCOSITY during process may require a speed change. For example, grease compounding kettles require different agitating speeds throughout the blending operation, if maximum efficiency is to be obtained. As mixtures become more fluid, agitating speed can be increased.

TO FORM DIFFERENT SECTIONS or portions of the product during the operation, speed changes may be required. For instance, a stocking knitter forms the welt at 190 rpm for about 500 revolutions. The speed then drops to 40 rpm when the welt is turned and knitted to the leg. Later, the machine must be speeded to 200 rpm while knitting the leg. There are at least 8 or 10 speed changes required in the production of a stocking because of the change in shape of the product. An efficient speed control greatly increases the output of such a machine.

INSPECTION OPERATIONS may require that speed be adjusted. Paper mills are being equipped with extremely slow speed controls so that the inspector can scan the product for flaws and stop the machine to cut out bad spots. Some textile machines, such as warpers, find it desirable to operate at low speeds while locating and tieing-in a broken end of thread.

STARTING OPERATIONS for many types of textile, paper, rubber, and plastic mill drives require adjustable speed so that a strip can be threaded through the rolls while they turn slowly.

Other Benefits

The designer will notice that all the above variations require a speed adjustment in order to maintain the highest productive speed for the main machine drive. However, it is obvious that there are other benefits that accrue in adjustable speed drive applications.

One important subsidiary benefit is that an adjustable speed drive often enables the buyer to minimize the equipment invested in other machinery. For instance, the grease compounding kettles previously mentioned were originally equipped with separate motors, each having a different operating speed. This was because different types of grease required different rates of agitation. When an adjustable speed drive was put on one of these compounding kettle drives, the manufacturer was able to dispose of other kettles because the one machine had sufficient versatility to make any kind of grease.

This benefit is also exemplified in test equipment, such as tachometer stands. By using an adjustable speed drive, a given tachometer stand can be adapted to many uses and therefore the user needs to buy fewer machines.

Control of quality is enhanced by adjustable speed. In the reel winding operation previously mentioned, adjustable speed enables tension to be controlled, and because the tension is uniform the quality of the yarn is better. Similarly, electrical coils can be made with more uniform performance because of uniform tension.

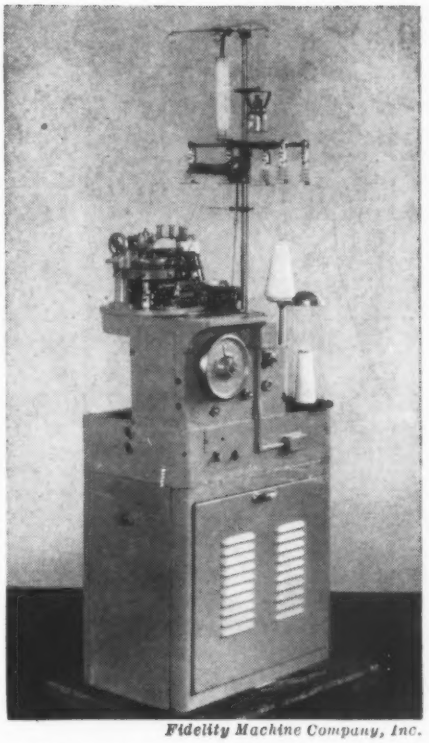
The quality of a finish may be determined by the speed of the operation. For instance, when using a grinding wheel or a certain grit on a given material, the finish can be very much affected by the speed.

In the canning operation, in which oranges were squeezed for their juice, it was found that an adjustable speed drive enabled the quality of the product to be improved because the speed of the press could be adjusted to suit the thickness of the skin. Therefore, unpleasant bitter oils were not extracted with the juice, yet the machine was operated at maximum speed consistent with the desired quality.

Every designer is aware of the possibilities for improving machine performance by reducing the time taken on non-productive motions. The most common example is the planer in which the return speed of the table may be as much as 120 times the cutting speed. An adjustable speed drive in combination with automatic control is the best solution to this problem. Similarly, return swing of a large power shovel can be much faster than when swinging with a load.

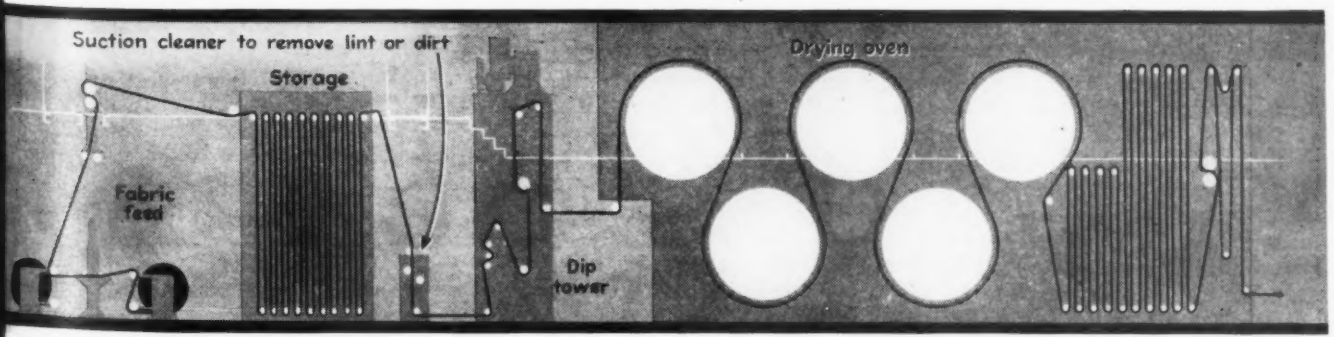
There is an endless list of applications of adjustable speed drives in combination with automatic control. Here the benefits of adjustable speed reach their maximum, and the future possibilities are tremendous.

The above analysis is only intended to outline general conditions under which adjustable speed should be considered. Designers in different fields will have their specific problems. But it should be evident to all that a great sales advantage is built into a machine with an adjustable drive; namely, maximum output under any conditions.



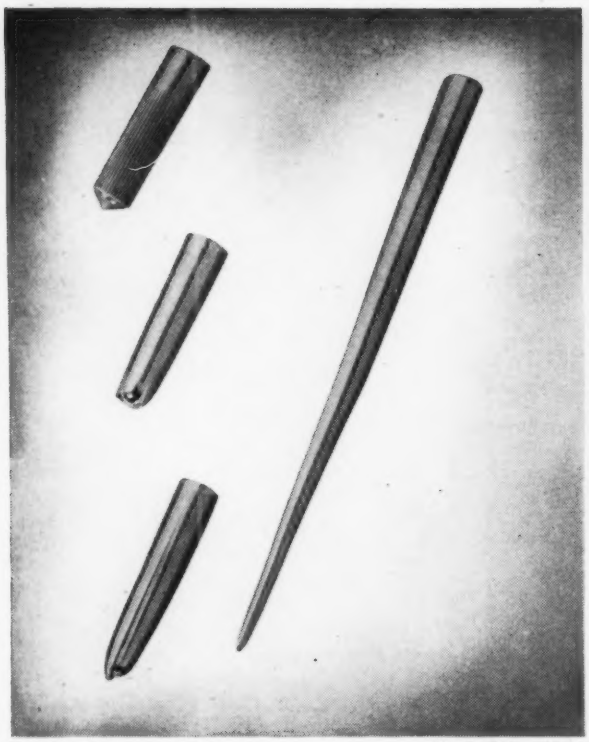
Fidelity Machine Company, Inc.

ELECTRONIC speed control was applied to this stocking knitter instead of conventional belt drive. Beneficial results: higher output, better quality, less floor space required, fewer operators needed.



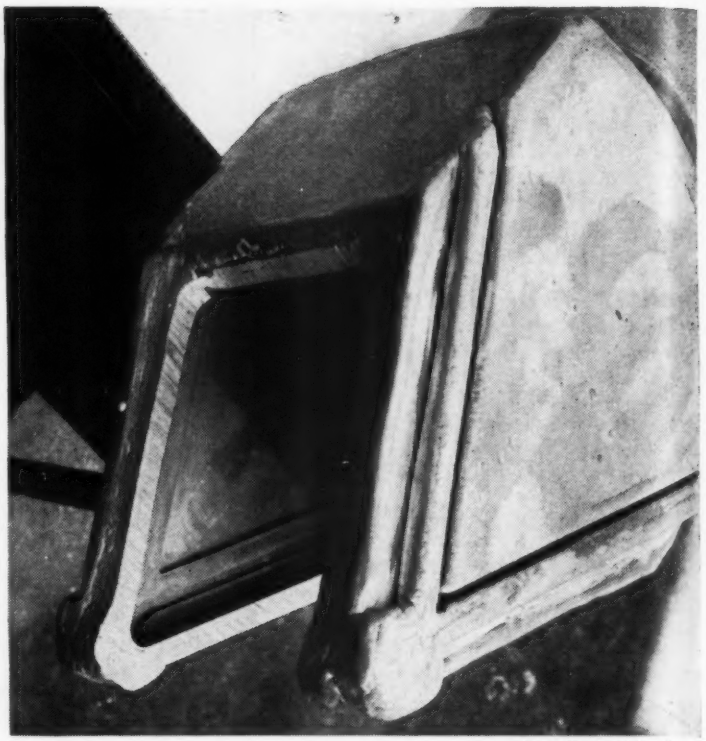
Dayton Rubber Company

several separate operations, which stretches, impregnates, and coats cords and fabrics with rubber at speeds up to 180 ft per minute.



Camin Laboratories

Fig. 1—New designs for pen caps exemplify the construction possibilities in electroforming. Unusual shapes, which are difficult to make by other methods, can be obtained.



Bone Engineering Corp.

Fig. 2—A seventy pound motor mount, electroformed of nickel for a jet engine installation, was produced more economically, for the quantity desired, than was possible with conventional methods.

Electroforming Difficult Shapes

Possibilities in joining, forming dies, bonding abrasives, reproducing detail, eliminating costly machining and making complex, accurate shapes by electrodeposition upon a shaped mandrel.

W. H. PRINE
International Nickel Company

ELECTROFORMING can well be referred to as a method of "cold casting." It is a process whereby a unit is fabricated by electrodepositing a shell of metal upon a removable mandrel or pattern. The process is applicable for manufacturing articles which cannot be produced economically by conventional methods.

The advantages of electroforming are greatest where internal or external dimensions require a great amount of machining, or where complex shapes require expensive and elaborate machining. Electroformed parts are not limited in wall dimensions as are regular castings, which are impossible to cast with very thin walls. When electroforming, the thinner the wall thickness, the more economical the operation; yet the strength of one piece construction is achieved. In addition, electroformed parts reproduce in detail the face of the mandrel. If a micro finish surface is desired on a complex interior section, it can be obtained by finishing the outside surface of the pattern to the desired degree of smoothness. By electroforming on this surface, the necessity for all complicated and expensive inside machining is eliminated.

The production of a fountain pen cap is an example of an article that incorporates many of the above advantages. Fig. 1 indicates possible electroformed designs different from the conventional patterns, which are restricted because of forming difficulties. In conventional fabrication, eight forming operations and tools for each operation are required for producing a pen cap. These caps are electroformed in one operation by depositing them upon a series of identical mandrels machined to inside dimensions of the finished cap. These mandrels pass through the plating solution and emerge from the bath with the pen cap in the completed shape, formed by electrodeposition. After trimming and polishing, they are ready for assembly.

Once the mandrel is obtained, practically any plater can electroform parts with equipment normally found in a plating shop. With fully automatic equipment, electroformed nickel pen caps are being produced at the rate of 40,000 per week. Shapes of similar contour and dimensions can readily be made on the same equipment simply by machining a number of mandrels having the shape of the finished piece. Better physical properties, closer tolerances and the incorporation of more novel features than can be accomplished by drawing are claimed. In addition, the method yields a 25 percent saving in production costs.

In contrast to objects the size of a pen cap, one electroplater recently electroformed in nickel a section of a jet motor mount which had a wall thickness of $\frac{1}{2}$ in. and weight of 70 lb. The unit possessed better mechanical properties and was closer in dimensions, in addition to being manufactured more economically, than conventional machining methods could produce.

During the war considerable work

was carried out in the production of precisely dimensioned radar wave guides. Only through electroforming was it found practical to achieve the close internal dimensions and smooth finish of the complex shapes involved. Dimensional tolerances of 0.0001 in. were common, and several times a tolerance of 0.00005 in. was met. The finish was required to be less than 4 micro-inches.

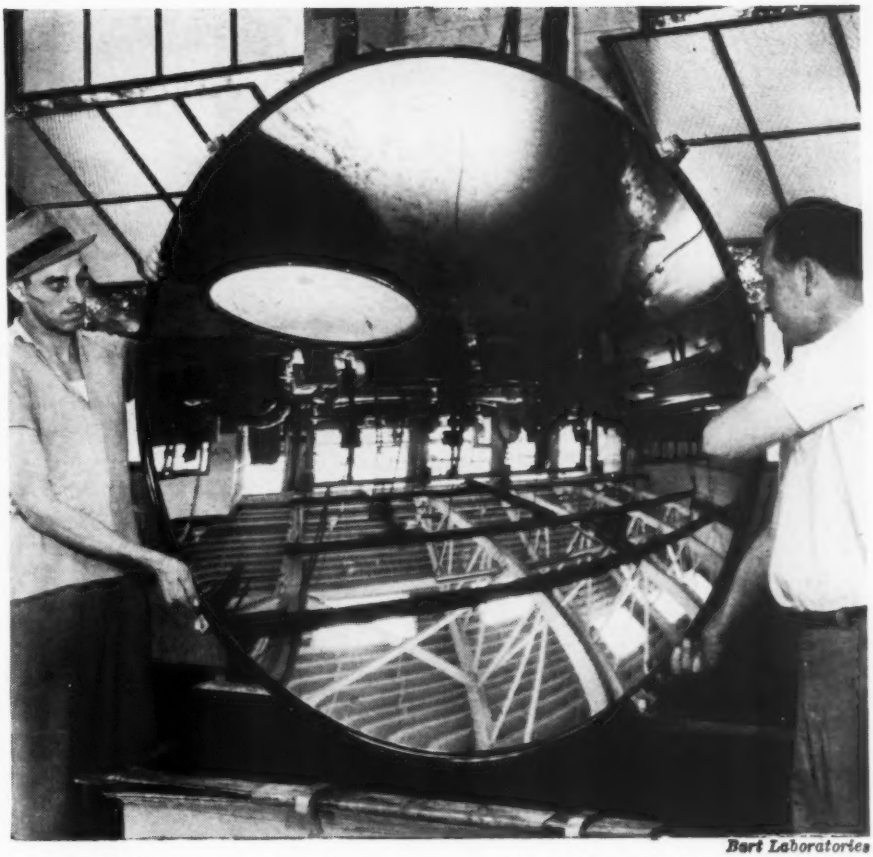
Another electroforming application is the fabrication of searchlight reflectors, Fig. 3. Nickel and copper are deposited upon a master glass mold made conductive with a film of silver. When the shell is electroformed to the desired thickness, it is separated from the mold, the silver is removed and the nickel surface is plated with a flash rhodium 30 millionths of an in. thick for reflectivity. Reflector signs for road warnings are an allied application.

Joining by Electroforming

Assembly of component parts is being accomplished in the electroforming of pitot static tubes. It is necessary that the separate air pressure compartments be assembled to contain resistance heaters and tubing, as shown in Fig. 4. The silver soldered skeleton containing the tubing, heaters and barriers *O*, *P* and *Q* has cast around it a mandrel of low melting alloy of lead-bismuth eutectic. The mandrel with the edge of the barriers exposed is then plated with copper until the shell is thick enough, 0.075 in., to have the necessary structural strength. The alloy is melted out through holes at *A*, *J* and *G*, by heating in an oil bath at 600 F. The outer surface is then ground, polished and nickel plated. This technique involves a unique method of assembly which would be extremely impractical by other means.

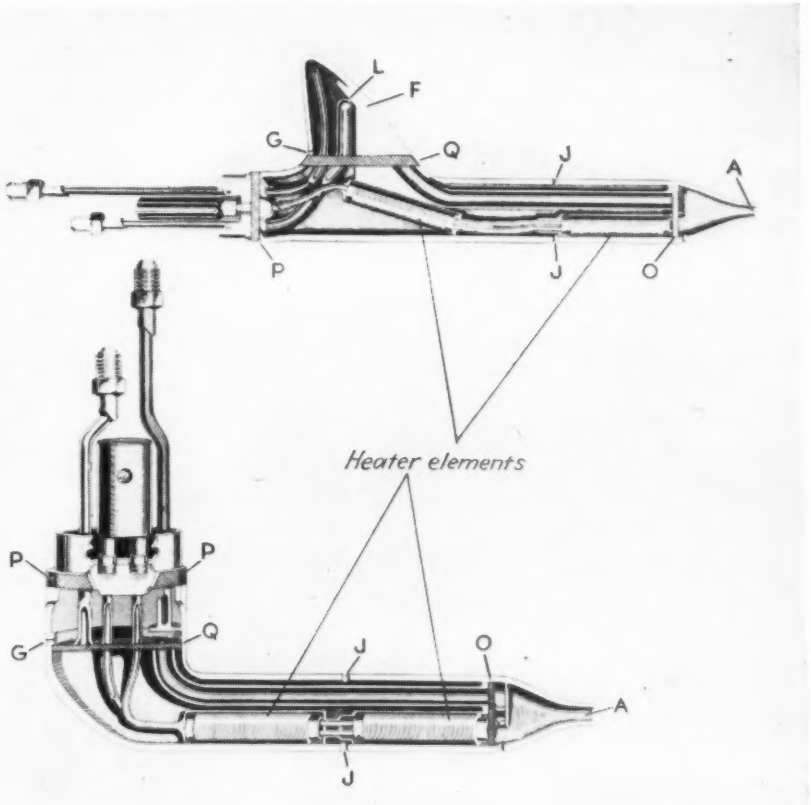
Electroformed Dies

At present several manufacturers are at various stages in the development and production of electroformed molds for casting plastics. The problem of the actual electroforming of the shell is of minor importance. Major consideration is the developing of a suitable method of backing up and reinforcing the shell. One solution is to continue the plating time until the shell is thick enough, say $\frac{1}{4}$ to $\frac{3}{8}$ in., to require no reinforcing. This thickness is of course dependent upon casting pressures. For example, a plastic casting die was made by building up a heavy nickel deposit, turning it down in a lathe and inserting it in the iron base. For very low pressure, slush type casting, electroformed dies are now being used for



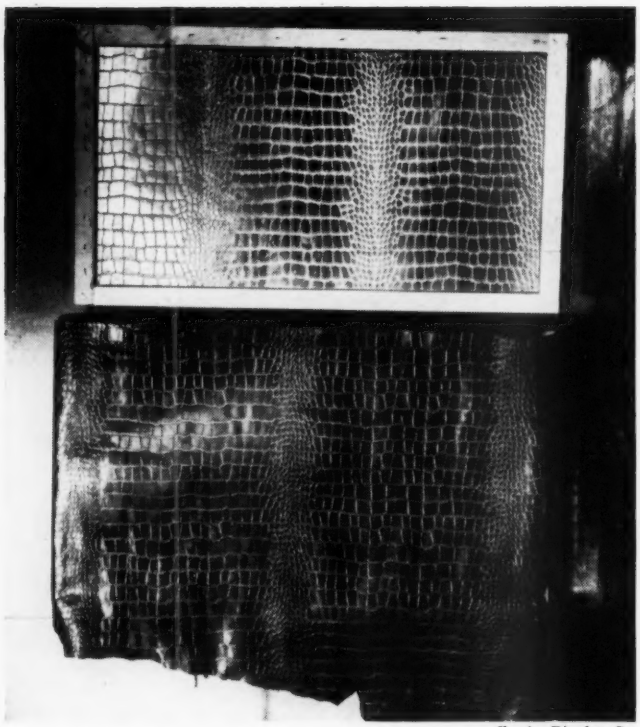
Bart Laboratories

Fig. 3—Nickel is electroformed on a master mold of glass which has been given a conductive film of silver. Copper is then plated on to the nickel to form the searchlight reflector which results when the combined deposit is stripped from the mold.



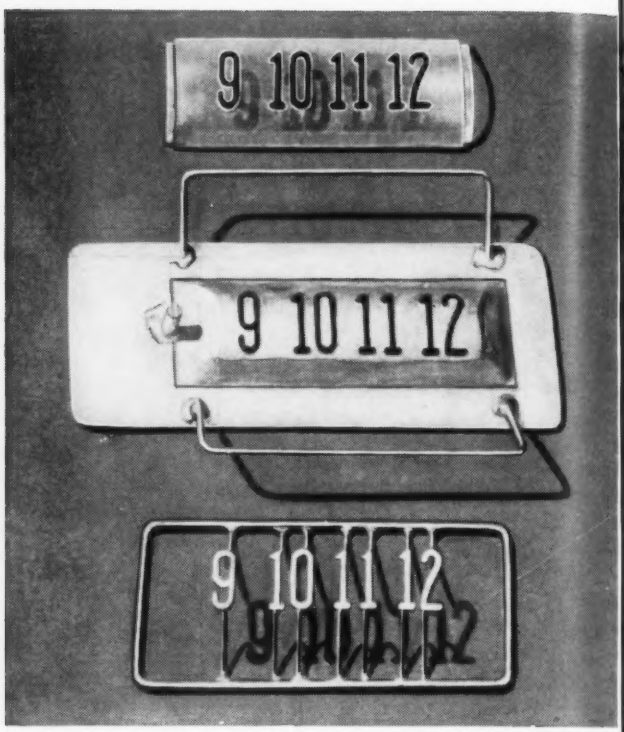
Kollsman Instrument Co.

Fig. 4—Pitot static tube showing details of the assembly which had been imbedded in a low melting alloy to form a mandrel around which the cover was electroformed to join barriers into air-tight compartments. Alloy was removed by heating in an oil bath.



F. A. Ringler Co.

Fig. 5—Electroformed graining die which was made by plating a heavy layer of iron on the leather surface after it had been made electrically conductive. Surface is accurately reproduced.



Conforming Matrix Corporation

Fig. 6—Electroformed paint mask for spraying plastic parts. The shell is electroformed on the part and the pattern to be painted then is cut out of the shell.

casting parts of such articles as toys and rubber products.

Complete reproduction of fine detail is a feature of electroforming. A great amount of the artificial leather finishes are produced by electroforming the embossing die upon the surface of an actual piece of leather which has been made electrically conductive. Fig. 5 illustrates the exact detail that can be obtained.

Bonding Abrasives

A unique method for the fabrication of abrasive materials is to electroform metals around the abrasive particles. Several patents have been granted covering a process for making diamond abrasive wheels by a series of operations as follows:

Industrial diamond chips are placed upon a flat circular area of graphitized wax. Copper is deposited upon the graphitized surface to a depth of approximately 0.003 in. Nickel is subsequently deposited to a thickness slightly greater than the depth of the diamonds thereby locking the diamond chips in place. The composite unit is then heated to melt the wax, the copper is dissolved away from the tips of the chips and the nickel layer serves as a bond for the diamonds. The nickel sheet containing the diamond chips is then cemented to a backing up ring or wheel. The advantages of this process are that the diamond chips are oriented to provide maximum cutting edge per unit weight of diamonds, and that there are fewer chips required since they are located only at the cutting surface and not scattered throughout the wheel as in a normal type abrasive wheel.

Although it was not pure electroforming, another thought was to produce marine anti-slip stair tread and deck covering by depositing a layer of nickel which had occluded particles of alundum to provide traction underfoot.

Accuracy of Shape

Production of the British "predictor" was an outstanding example of the advantages of electroforming. The unit consisted essentially of a complex shaped cam which, in conjunction with radar, would pick up the flight of the V-1 flying bombs, compute the line of flight and sight the guns to fire to intercept the missile. The cam resembled an eccentric truncated cone with a spiral effect on the surface. The design of the cam required 180,000 computations; 30,000 fixed points were held to dimensional tolerances of 0.0001 in. on each cam. One and one-half years were required to make the calculations and the actual machining of the first cam required six months. Since this rate of production was impractical, a slightly oversized cavity was hobbed out of steel, the machined cam was placed in the cavity with clearance on all sides; one of the Cerro alloys was poured into the space around the cam after placing a parting compound on the cam surface. The cam was removed and nickel was electrodeposited upon the alloy cavity wall. After building up to a sufficient thickness, the electroformed cam shell was removed by melting out the low melting alloy. This procedure produced exact duplicates of the master at the required rate.

Other Applications

Electroformed copper-nickel screens are produced in continuous lengths. These screens are of extremely fine mesh with uniform openings. A 400 mesh screen is produced in sizes up to 6 in. square. Mesh size variation is $\pm$ 4 percent.

Electroformed masks for stopping off during paint spraying provide sharper detail and permit the design of more complex masks than can be made by hammering, bending and brazing construction. For instance, if a plastic panel with recessed figures is to be sprayed with various colors, the panel itself is given a conductive film and a shell is electroformed on this surface. This shell is removed, the sections through which paint is to pass is cut out with a jeweler's saw, cut outs are connected by soldered wires and a handle is attached to provide a completed mask. Fig. 6 portrays types of electro formed masks.

Electroforming is usually carried out

with copper, iron or nickel and occasionally other metals. Each metal provides some advantages over the other so that it is dependent upon the object to be electroformed and the use to which it is to be applied, one metal or a combination of two will have a distinct advantage over any other use.

Compared to the other two metals, electroformed copper is relatively stress free but has low strength and hardness properties; it can be deposited at high rates but requires heavier deposits in order to obtain equivalent strength.

Iron has the lowest metal cost, possesses intermediate physical properties but can be heat-treated to produce a case hardness of 675 Brinell, although warpage can be encountered as a result of treatment.

Nickel can be deposited with a hardness of 150-425 Brinell with corresponding ductility values of 30-6 percent respectively in 2 in. and tensile strengths of 51,000-152,000 psi. These values are controllable and are dependent upon solution composition, pH and temperature. Nickel offers the advantages of good physical properties and the inherent good corrosion resistant qualities of nickel itself.

Some electroformers utilize laminated layers of nickel-iron-nickel to obtain the low stress properties of the iron and the good physical properties and corrosion resistance of nickel.

Table I includes the physical properties of the more popular metals used for electroforming. These values indicate properties obtainable in the "as plated" state.

Procedure

The mandrel can be made of a low melting alloy, aluminum, wax, plastic, plaster of Paris, wood, stainless steel, or almost any material which can be made impervious to water and be made electrically conductive. The mandrel may be cast, machined or formed by any means to obtain the desired shape. If it is desired that a plastic casting mold be made, it can be electroformed by depositing it upon an actual unit that was produced in another mold.

The so-called permanent mandrels can be made of plastic chromium plated steels or stainless steel, although stainless steel is by far the best for dimensional accuracy and ease of processing. Any non-conductor must be made conductive and entails additional operations. Stainless steel is electrically conductive and it also possesses the advantages of exhibiting a passive surface. Unless the stainless steel surface is specially processed, this passive film will prevent adhesion between the electrodeposited shell and the stainless steel mandrel. This lack of adhesion permits removal of the deposit by exerting a slight rolling pressure on the shell. If the rolling operation is impractical, Invar can be used. The parting is then made by immersing the part in boiling water; the electroformed shell expands and separates from the Invar mandrel.

There are several low melting point alloys of the lead, tin, bismuth type. The three most common of these alloys, Cerrobend, Cerrobase and Cerrotru, manufactured by Cerro de Pasco Corporation, melt at 158 F, 255 F and 281 F, respectively. The Cerrobend can therefore be melted out with boiling water and the Cerrobase and Cerrotru can be removed by heating in an oil bath or in an oven. Using Cerrotru, dimensional accuracy of 0.0002 in. can be obtained, whereas allowance must be made for growth of the Cerrobase and Cerrobend alloys. All may be reused after melting out of the electroformed unit. Because of the high density and the low physical properties of these alloys, it is sometimes necessary to produce "slush" castings in order to prevent sag in very large shapes since all of the Cerro Alloys are subject to creep or cold flow.

For relatively large mandrels where this cold flow is a factor and where weight would be important, aluminum has been used. After the electrodeposition, the aluminum is removed by dissolving in dilute alkalies.

Typical Applications

Phonograph record stampers
Pitot static tubes
Radar wave guides
Computer cam for fire direction
Electrotype and stereotype plates
Mould cavities for plastics
Leather embossing plates
Foil
Thin wall tubing
Precision mesh screen
Venturi meters
Reflectors
Machine parts

The above list includes some of the major applications. These and many other allied products can be made by electroforming to take advantage of the unique merits of this principle for making a better product or making it more economically.

Table I—Physical Properties and Plating Solutions for Electroforming

Physical Properties

	Hardness (Vickers)	Ductility (Percent elongation in 2 in.)	Tensile psi
Copper	80	22	36,000
Iron	240	15	50,000
Soft nickel	140–160	30	51,000
Medium nickel	230–260	21	98,000
Hard nickel	350–475	6	150,000

Composition of the solutions and operating conditions which produce the above physical properties

Copper		Iron	
Copper sulphate crystals	27 oz/gal	Ferric chloride	50 oz/gal
Sulfuric acid	65 oz/gal	Calcium chloride	25 oz/gal
Temperature	75–120 F	pH	6–10
Current density (normal)	15–40 amps per sq ft	Temperature	185–195 F
		Current density (normal)	50–100 amps per sq ft

Nickel	Soft	Medium	Hard
Nickel sulfate	44 oz/gal	.....	24 oz/gal
Nickel chloride	6 oz/gal	40 oz/gal	.....
Ammonium chloride	.....	.....	3.3 oz/gal
Boric acid	5 oz/gal	4.0 oz/gal	4.0 oz/gal
Temperature	115–140 F	140 F	110–140 F
Current density	25–100 amps per sq ft	25–100 amps per sq ft	25–50 amps per sq ft

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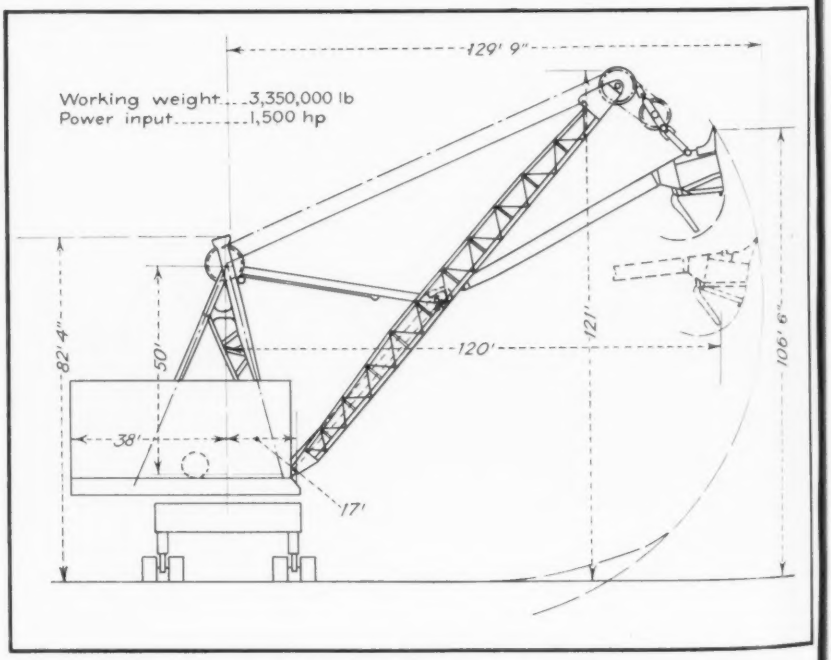
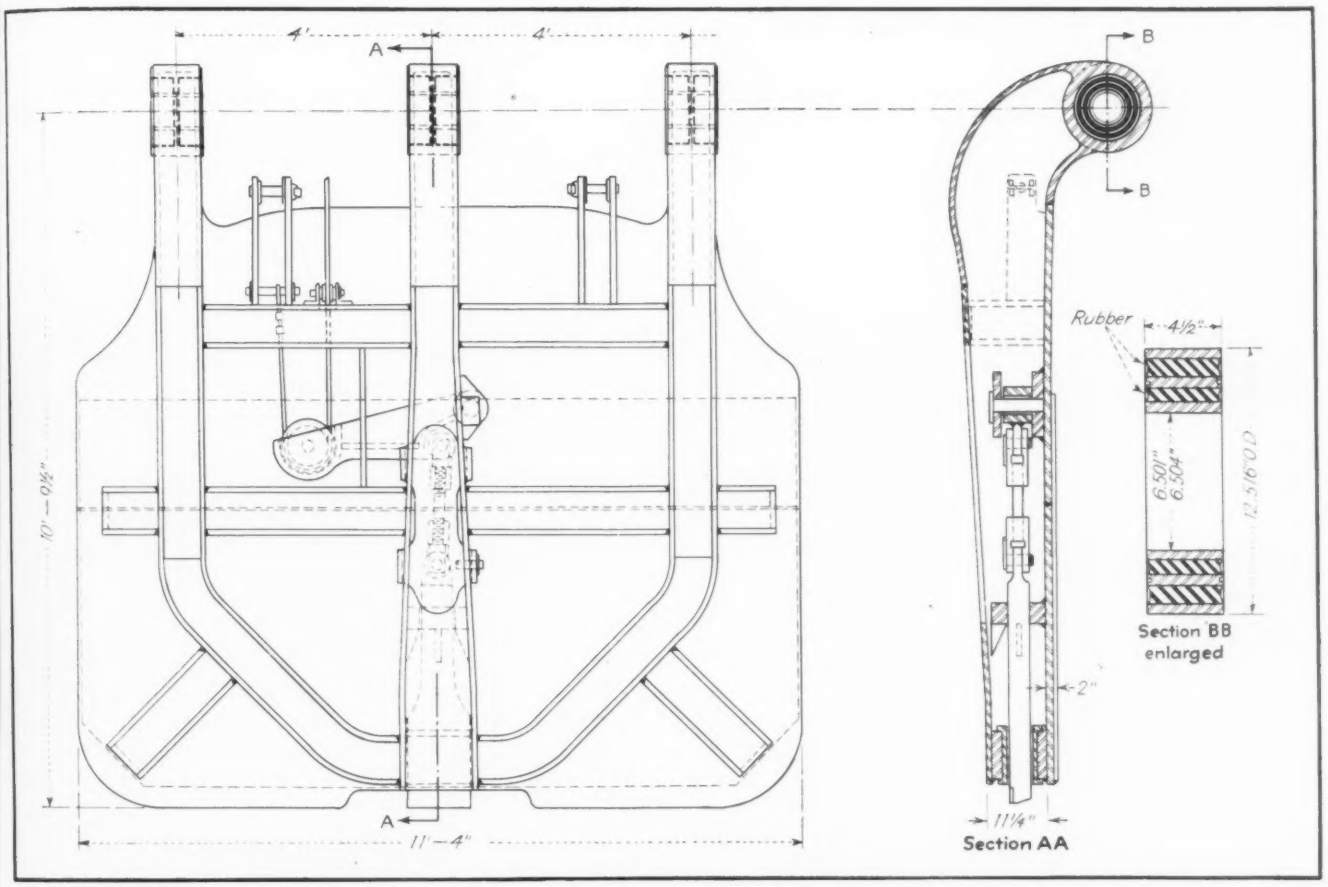
BOOM WAS LIGHTENED and lengthened by use of low alloy structural steels. Truss construction, to reduce deflection under compressive loading, has Tee section alloy chords with welded pipe cross bracing members.

Alloy Steels Increase Shovel Capacity

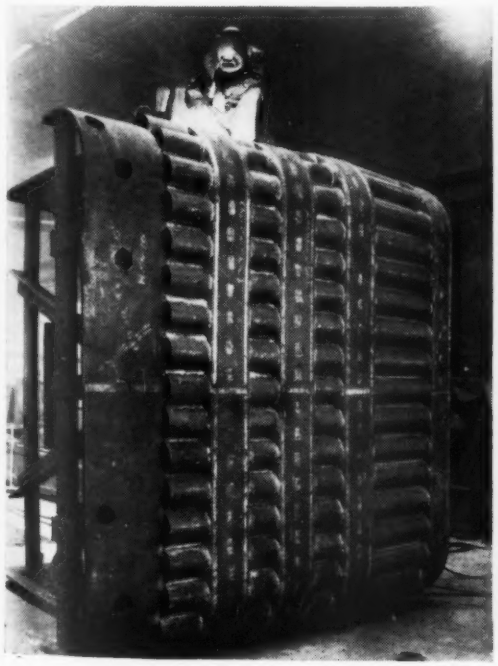
Modified armor plate steels were used to increase the capacity of Type 5561 Marion shovels from 35 cu yd to 40 cu yd. Cutting effort at tip of dipper was increased 33 percent and operating range was also increased. Changes did not increase the weight of the shovel or the power requirements. Ground pressure of 52 psi was not increased by improvements to machine.



SHOVEL IS ELECTRICALLY OPERATED. Power is supplied at 4,000 v. 3 phase, 60 cycles and converted to d-c. The Ward-Leonard system is used with rotating-regulator type exciters for rapid reversing and quick response. Duplicate operating controls are located in pulpits on each side of front.

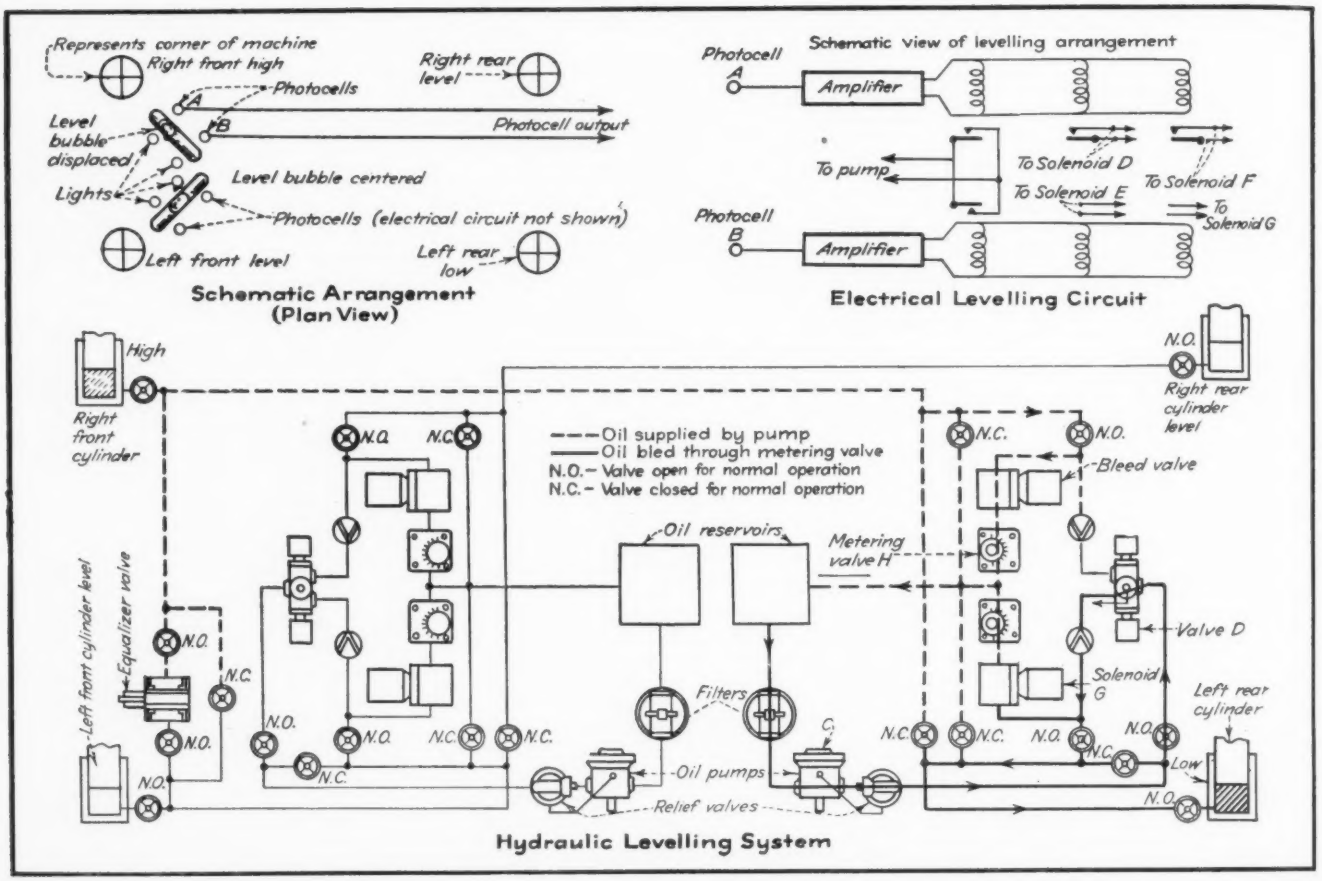


RUBBER HINGE BUSHINGS absorb shocks and divide load between the three hinges. Weldments replaced castings for dipper bottom and hinge parts. Nickel-manganese steel was used for parts subject to abrasion.



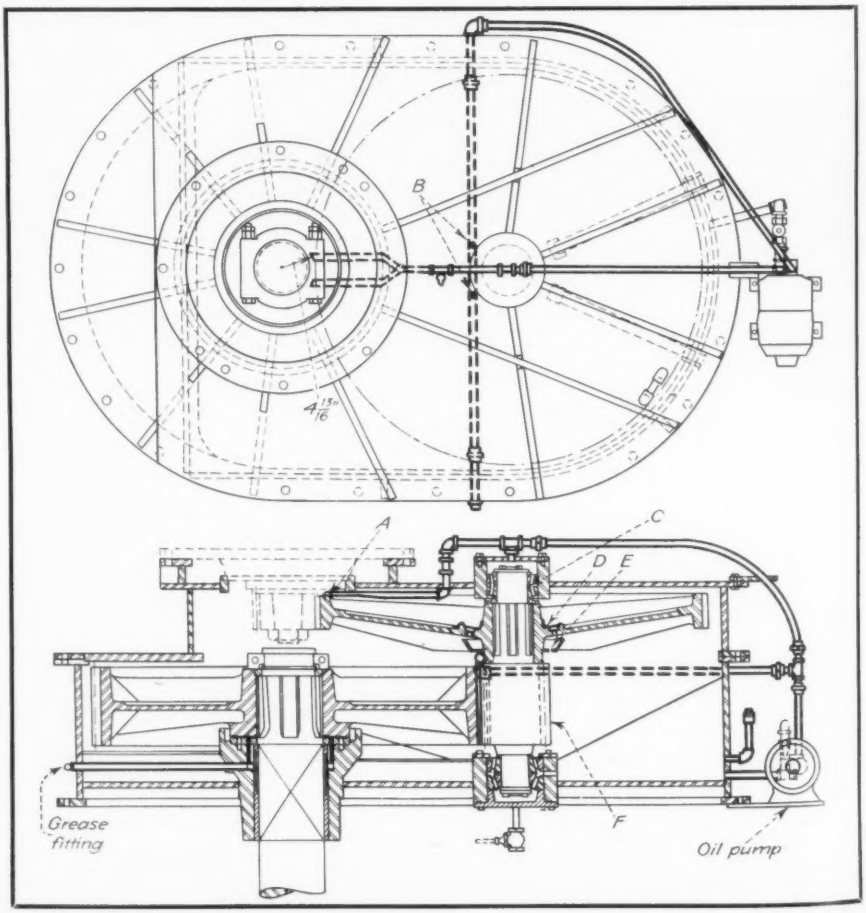
SEMI-TUBULAR REINFORCEMENTS resist compression loads caused by cutting effort on dipper teeth and stiffen front of dipper. Use of thinner steel is thus compensated for.

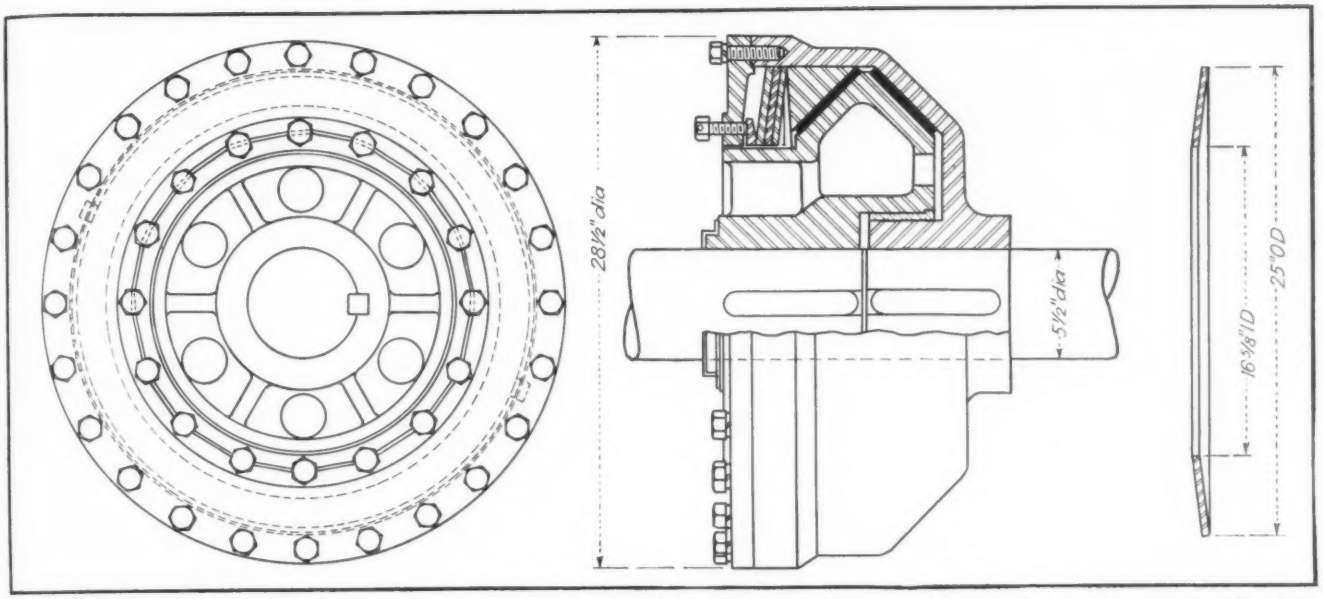
STEERING is accomplished by turning crawler units by motor driven screw shafts and nuts. Front and rear pairs can be steered independently. On uneven ground crawler frames rock transversely and each track assembly rocks independently in a longitudinal direction.



LOWER FRAME is levelled by transferring oil between 4 hydraulic jacks on crawlers. If right front is high, level bubble moves in front of photocell *A*. Resulting current change is amplified to start oil pump *C*, open three way valve *D* and bleed valve *F*. Pump forces oil into left rear jack while metering valve *H* bleeds right front jack at the same rate. A similar system levels left front with right rear. An equalizing valve balances the two rear jacks when propelling to give the effect of three point support.

BECAUSE REVERSING operation, vertical gear axes and heavy tooth loads tend to remove oil from teeth, lubricating oil is pumped directly to meshing teeth of gears in drive for rotation of shovel. Pipes *A* supply oil to meshing points of first reduction. Holes *B* in cross pipe supply oil to meshing points of second reduction. Oil flowing from upper bearing on intermediate shaft *C* is caught in basin on gear *D*, flows through holes in web into pan *E*. Holes in pan allow the oil to drip on teeth of pinion *F*. Final bearing is grease lubricated.

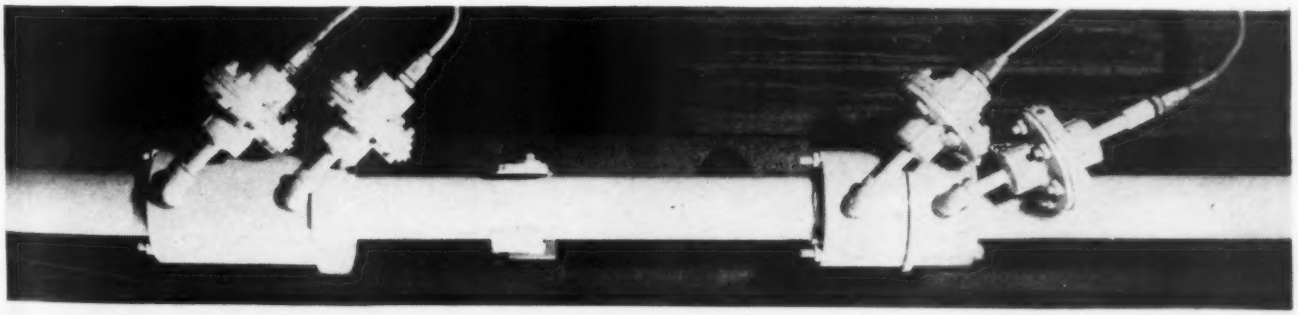


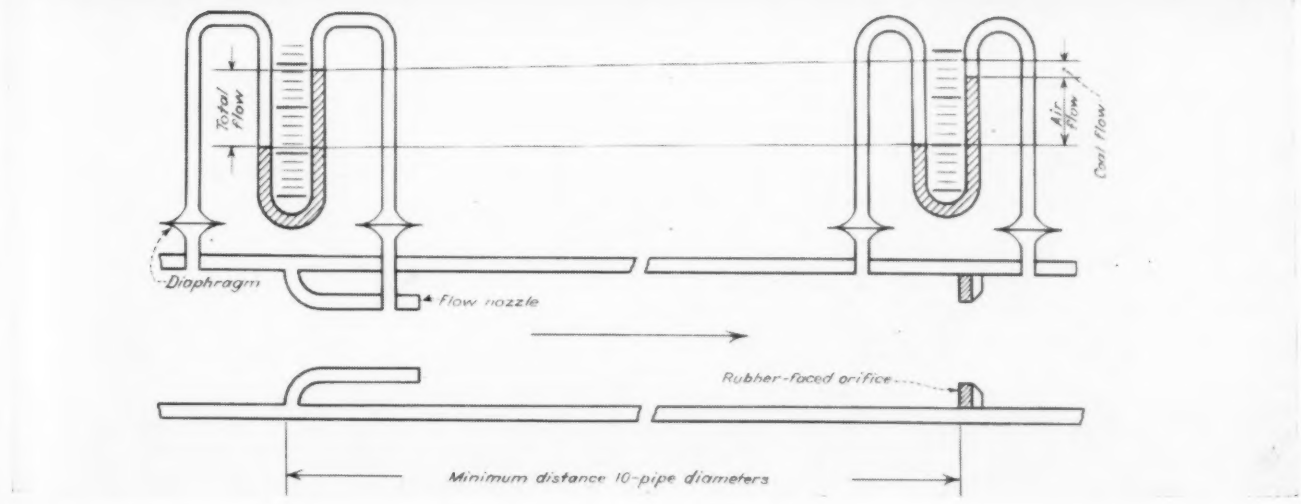


TORQUE limiting couplings protect each crawler unit drive against overloads. Propulsion power is supplied through gearing from hoist motors. Coned friction surfaces slip at torques over 440,000 lb-in. Low-rate Bellville springs reduce changes in slipping torque as linings wear and permit compact design of clutch.

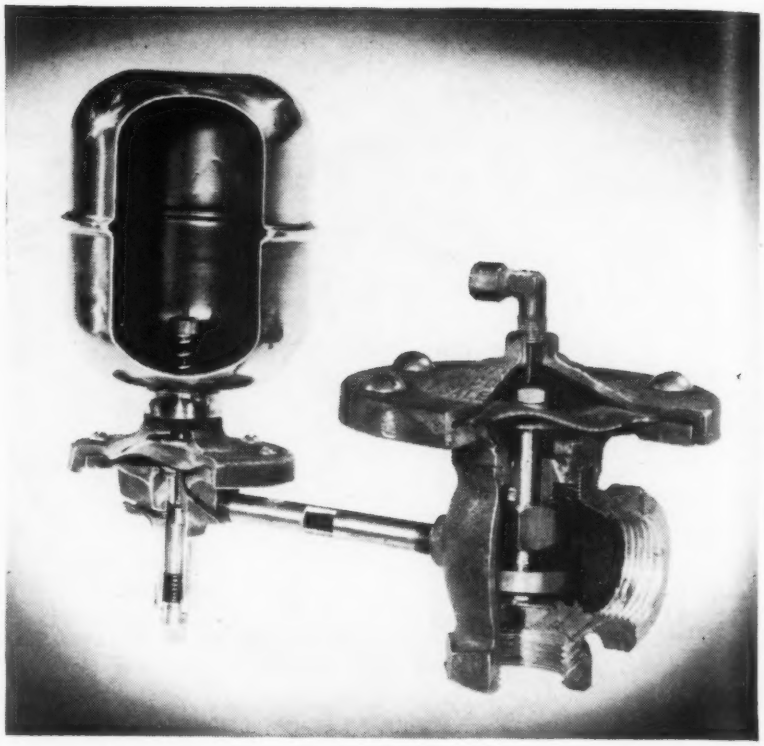
Flowmeter Measures Entrained Solids

A streamlined nozzle and a sharp edge orifice are used in series to measure pulverized coal in a flowmeter developed at Battelle Memorial Institute. Pressure differential across nozzle measures weight of coal and air. Differential across orifice measures air weight only. Coal flow is determined by a formula. Orifice plate is rubber faced to prevent abrasion by coal particles. Filters isolate meters from contamination by coal particles.



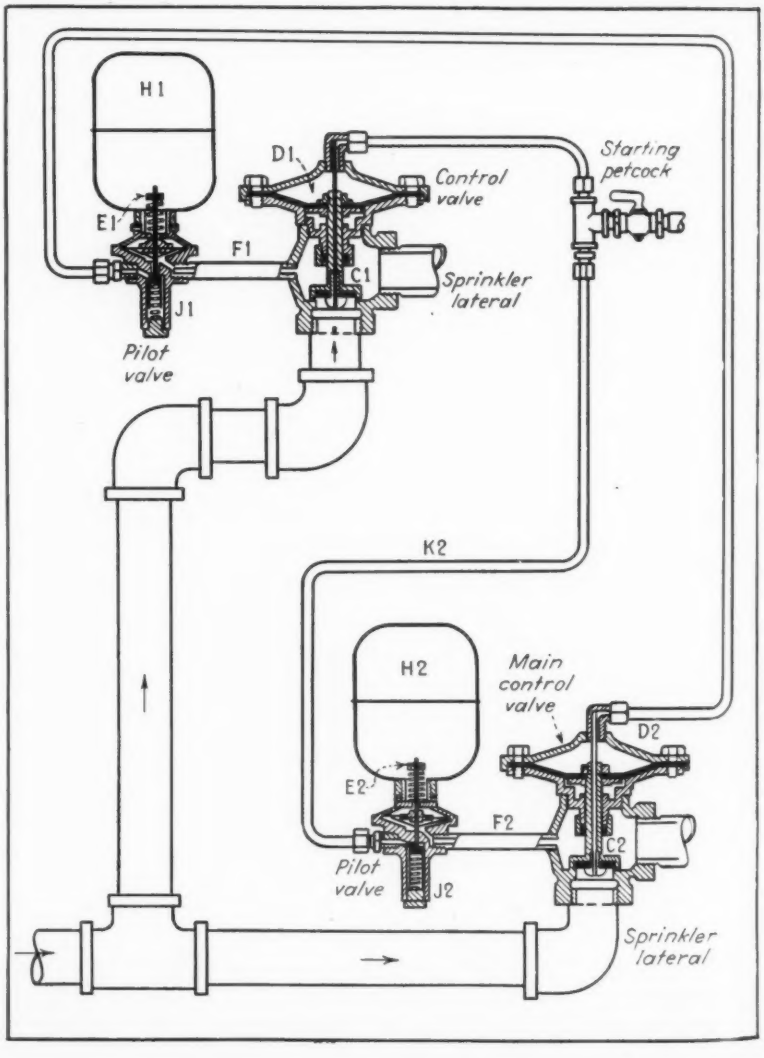


Hydraulic Sequence Control Operates Sprinkler System

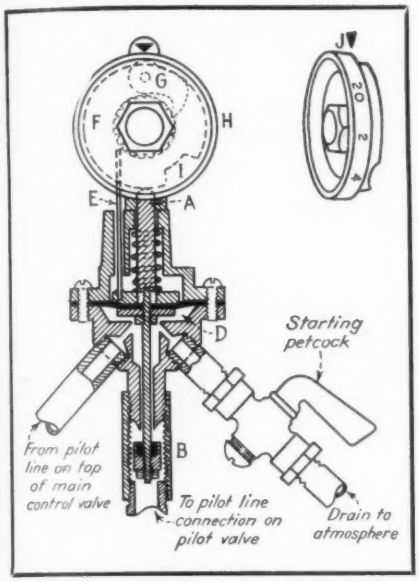


Hydraulic sequence control units operate in series to permit use of one standard mechanism for any number of groups of sprinklers. To reduce pressure losses and simplify piping, a control may be mounted near its sprinkler group and connected by small pilot tubing to preceding and following units. Simplest system is started and stopped by hand. Semi-automatic unit shuts off automatically after selected number of cycles. Fully automatic system applies water for selected periods at desired times during the week. These "Automistic" controls are made by Lake Union Sales Co., Seattle, Wash.

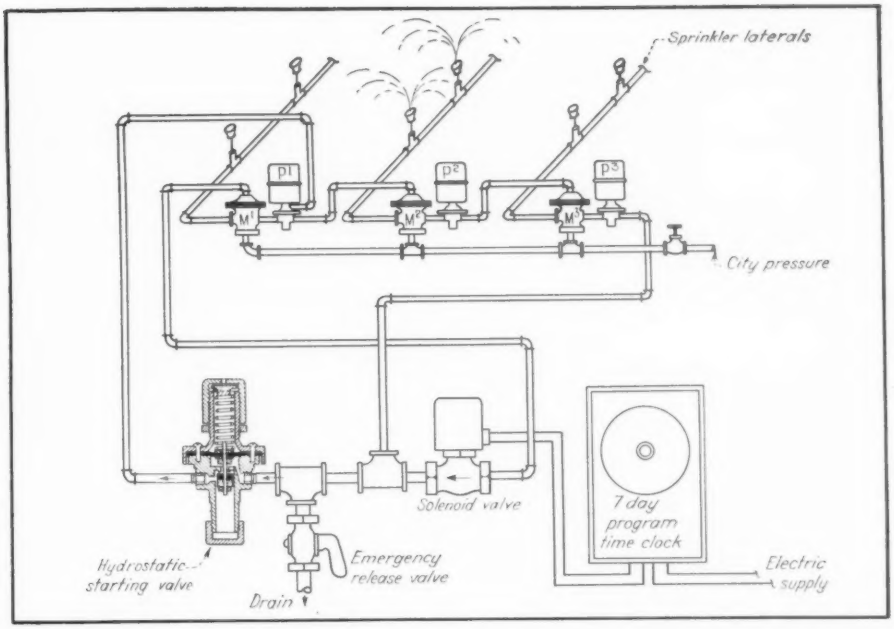
Each unit of sprinkler system feeds one group of sprinklers. Units can be adjusted to supply water to each group in rotation, for periods of 1 to 4 min to suit requirements of shady or sunny areas of planting.



WHEN THE SYSTEM is at rest, water pressure is applied to the diaphragm chambers *D* 1 and *D* 2. Opening the starting petcock for about 30 sec releases pressure in *D* 1, control valve *C* 1 lifts and water flows through sprinkler group 1. At the same time, water flows through the hollow stem of *C* 1 into *D* 1, and through *F* 1 compressing air in *H* 1. As pressure increases in *D* 1 it closes *C* 1 and ultimately shuts off flow to group 1. When this happens the pressure in group 1 and in *F* 1 drops, and water flows out of *H* 1. This reverse flow opens valve *J* 1 and bleeds chamber *D* 2 on control valve 2. The latter goes through a similar cycle and, in turn, starts control valve 1. Increasing tension of spring *E* 1 decreases the duration of flow through control valve 2 by decreasing the rate of bleed from *D* 2. Flow through the stem of control valve 2 then causes the valve to close more quickly. Two units are shown for simplicity but as many units as necessary can be connected in series.



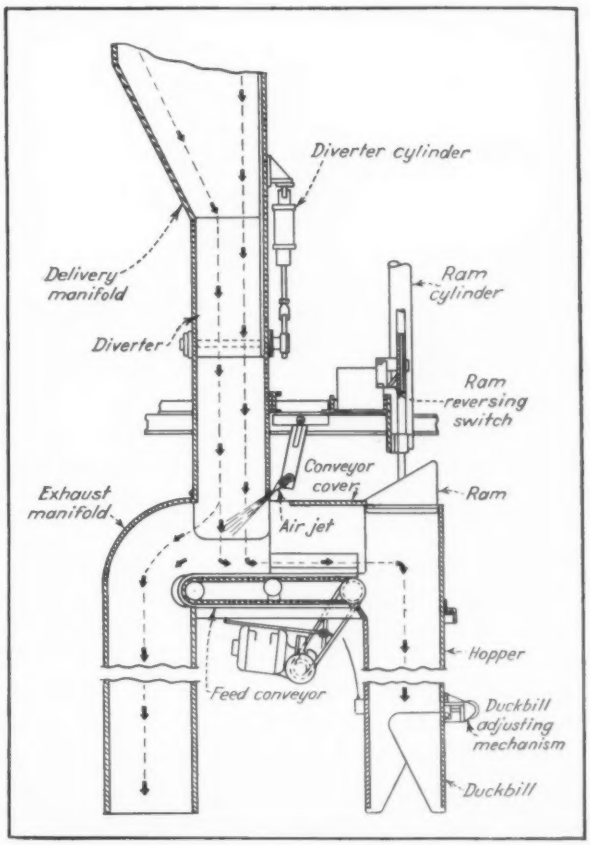
AUTOMATIC SHUT OFF is obtained by setting dial *H* so that desired number of cycles appears opposite index *J*. The starting petcock is then opened manually and reclosed. During each cycle, pressure applied under diaphragm *D* lifts push rod *E* and causes ratchet *F* to advance dial *H* one notch. When recess *I* aligns with plunger *A*, water pressure closes valve *B* and shuts off the system.

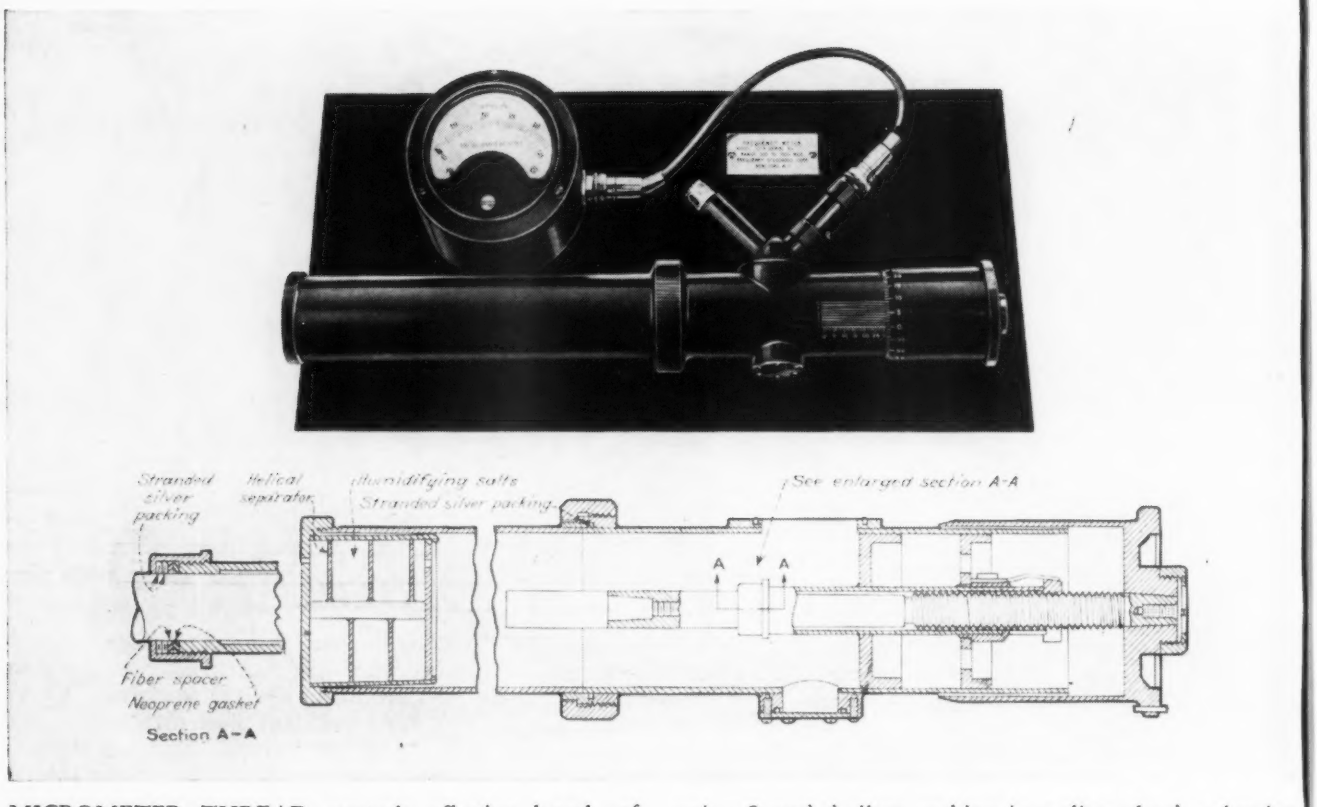


IN THE FULLY AUTOMATIC SYSTEM an electric program clock is set to energize the solenoid valve for desired operating times. At the beginning of an operating period, the solenoid valve opens and allows water to bleed from control valve *M* 1 through the open hydrostatic valve into the compression chamber of pilot valve *P* 1. Valve *M* 1 then opens to supply its group. Pressure increase in the compression chamber of *P* 1 closes the starting valve and the units operate in rotation as described. At the end of the preset time interval, the solenoid valve closes and stops the operation. Pilot valve *P* 3 then remains open and bleeds the starting valve to cause it to open, ready for the next cycle.

Air Blast Controls Accurate Weight of Packaged Insulation

AN AIR BLAST DIVERTS excess rock wool insulation from weighing system in the packaging machine developed by the Union Bag and Paper Corp., New York, N. Y. Material is fed alternately into two conveyors mounted on individual weighing mechanisms. At the ends of the conveyors, and also mounted on the weighing mechanisms, are hoppers with air operated duck bills which expand to hold bags in position, and provide airtight closures. When the desired weight of material has passed onto the conveyor, a diverter in the feed spout transfers the continuous flow of rock wool from the filled conveyor to the empty one. The weight of the falling column of insulation between diverter and conveyor cannot be predicted accurately. So a timed air blast ejects this excess material into an exhaust manifold from which it is recycled. A time-switch permits the loaded conveyor to run long enough to empty all materials which were weighed into the packaging hopper. When the time-switch completes its cycle, a pneumatically operated ram compresses the rock wool in the bag to a fixed load line. The machine is enclosed so that practically none of the hazardous rock wool dust is released in the working area.

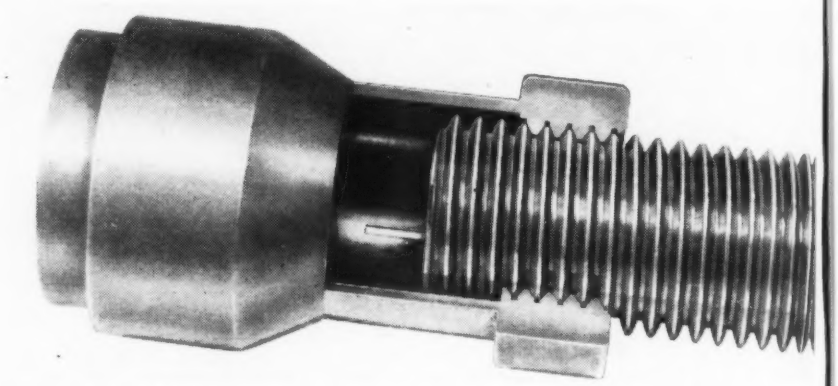




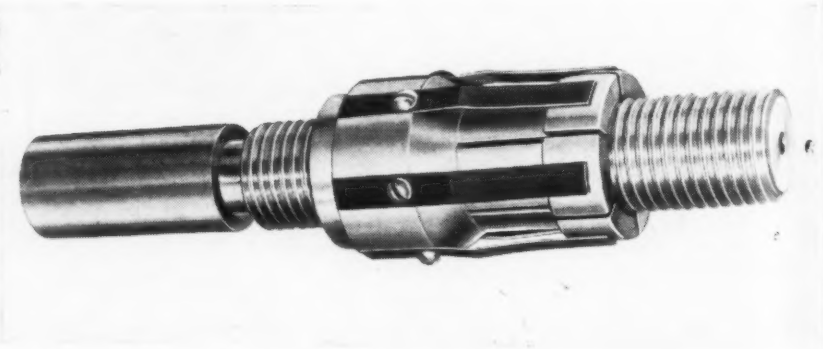
MICROMETER THREAD controls effective length of inner conductor which determines resonant frequency of unit. Stranded silver packing in sealing gland makes low resistance contact between inner and outer conductors.

Precision Thread For Frequency Meter Adjustment

Total allowable error is 0.000012 in. in micrometer thread assembly of precision frequency meter made by Frequency Standards Corp., New York, N. Y. Split nut and undercut thread compensate for wear and backlash to meet this requirement. Dessicators would require frequent replacement because of high water absorption so salt mixture is used to hold humidity constant at a level requiring minimum average change in air admitted to measuring cavity.



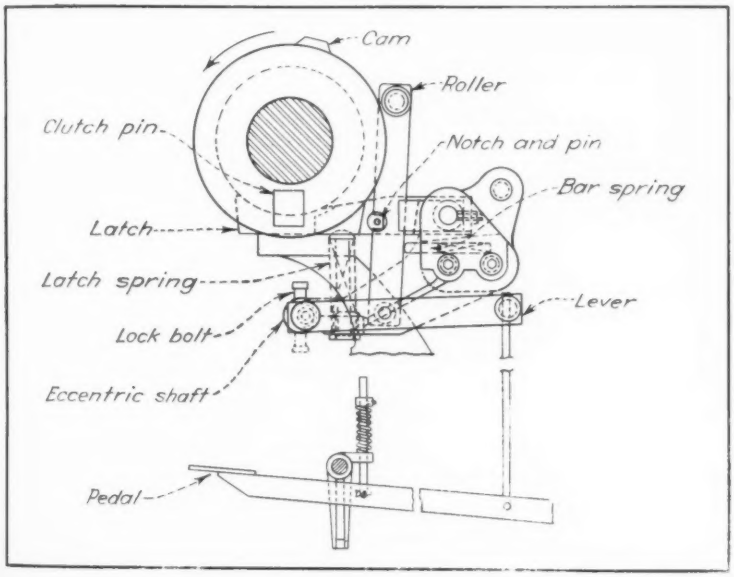
THREAD ROOTS are undercut to localize bearing on flanks of thread preventing interference due to wear. Engagement of four threads averages minor helix errors.

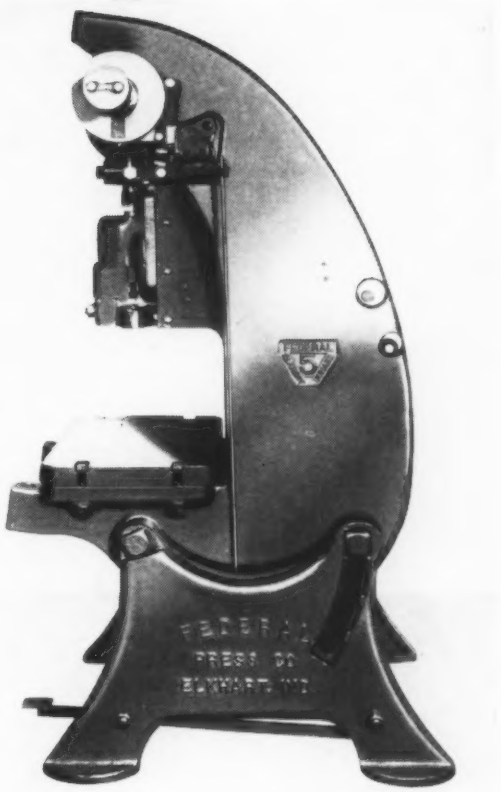


NUT IS SPLIT and spring loaded to maintain constant contact between thread flanks. Nut and screw are made of Invar. Screw is plated to prevent galling.

Non-Repeat Safety Clutch

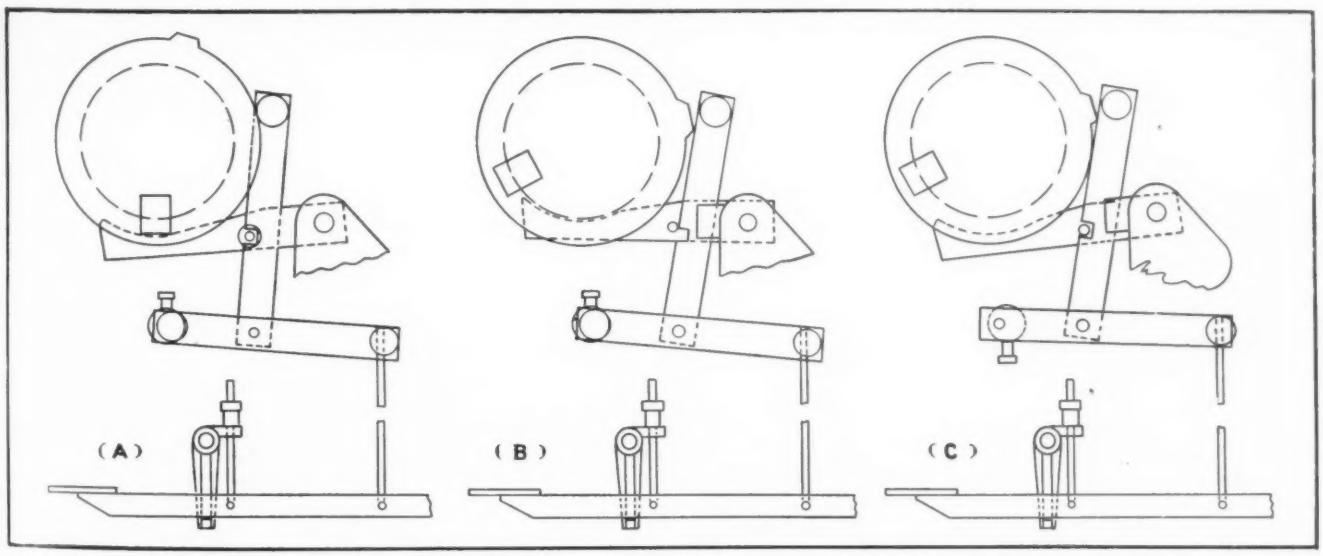
Operating bar of Federal non-repeat safety clutch is disengaged by a cam on the press crankshaft to prevent repetition of press cycle until operator has released foot lever to reset mechanism. The operator can lock out the single cycle mechanism without using tools or leaving his working position. Press then continues to operate as long as pedal is held down. The Federal Press Co., Elkhart, Ind. applies this device to their open back inclinable presses.





CLUTCH MECHANISM is located between press frame and flywheel, which has been removed in this view.

IN IDLE POSITION, bar spring holds notch in bar over pin in latch. Latch spring holds latch up to retain clutch pin in disengaged position.



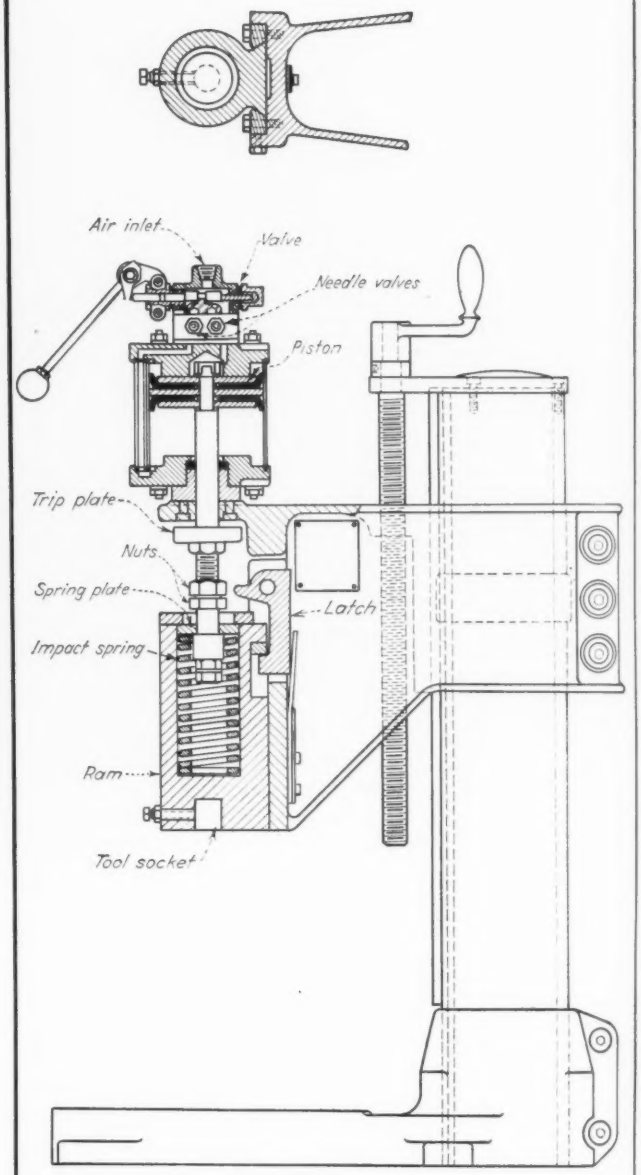
(A) Depressing pedal rotates lever. This pulls down bar and latch allowing clutch pin to move out and engage clutch. (B) Cam contacts roller and rotates bar until notch clears pin. Latch then rises and retracts clutch pin stopping the press. Pedal must be released to engage notch and pin before another cycle can be obtained. (C) For continuous operation, lock bolt is rotated through 180 deg. This causes eccentric shaft to move the lever pivot to the left. Roller now clears cam and press operates continuously as long as pedal is depressed.

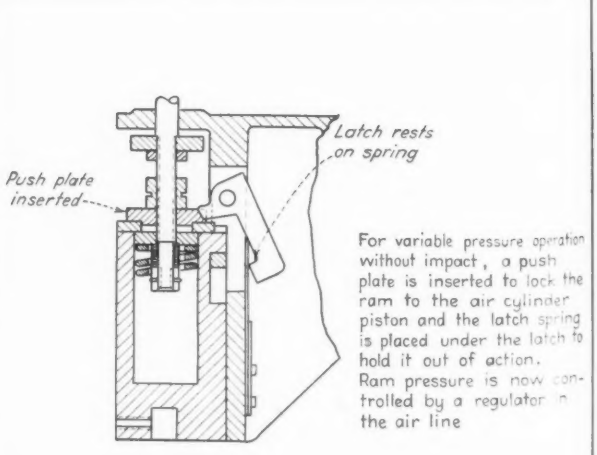
A TWO HAND SAFETY CONTROL, foot pedal or similar device can be used to actuate the press. Maximum vertical clearance is $13\frac{7}{16}$ in. and throat clearance from center line of ram is 7 in.

Air Actuated Impact Press

An air cylinder compresses actuating spring of the Bellows Impact Press. The press ram, released when spring reaches pre-selected compression, travels $1\frac{1}{4}$ in. to strike a maximum blow of 6,500 lb. The impact mechanism can be locked when a steady pressure is desired. Press is made by the Bellows Co., Akron, Ohio.

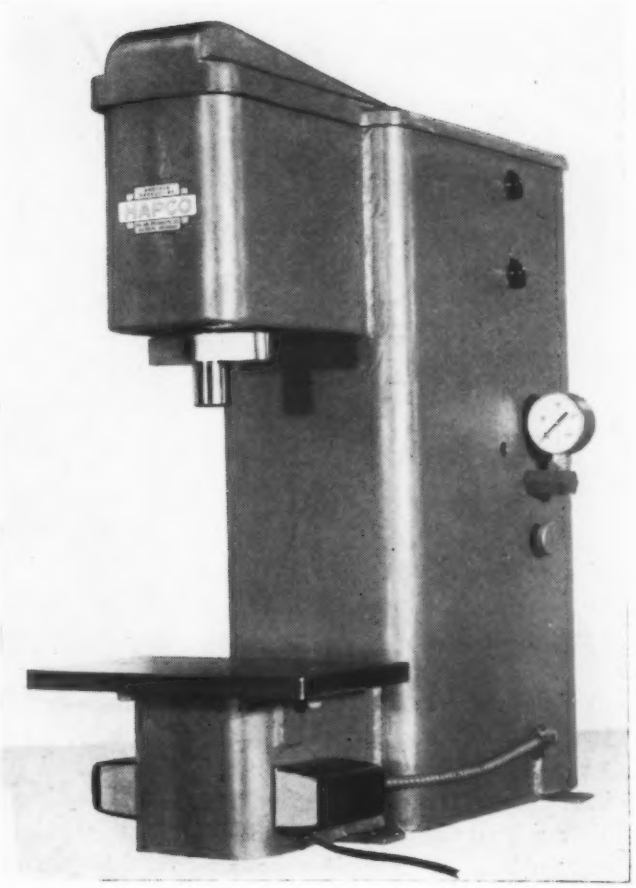
AT START OF CYCLE, latch supports ram. Operation of valve applies air pressure to top of piston. As piston moves down, nuts on piston rod contact spring plate and compress impact spring. At end of piston stroke, trip plate on piston rod releases latch. Impact spring then drives ram down. The position of nuts on piston rod determines spring compression and resulting impact force. Releasing the air valve exhausts the head end of the air cylinder and applies pressure to the rod end to lift ram and piston. Needle valves in air passages are adjusted for smooth operation of the air cylinder.



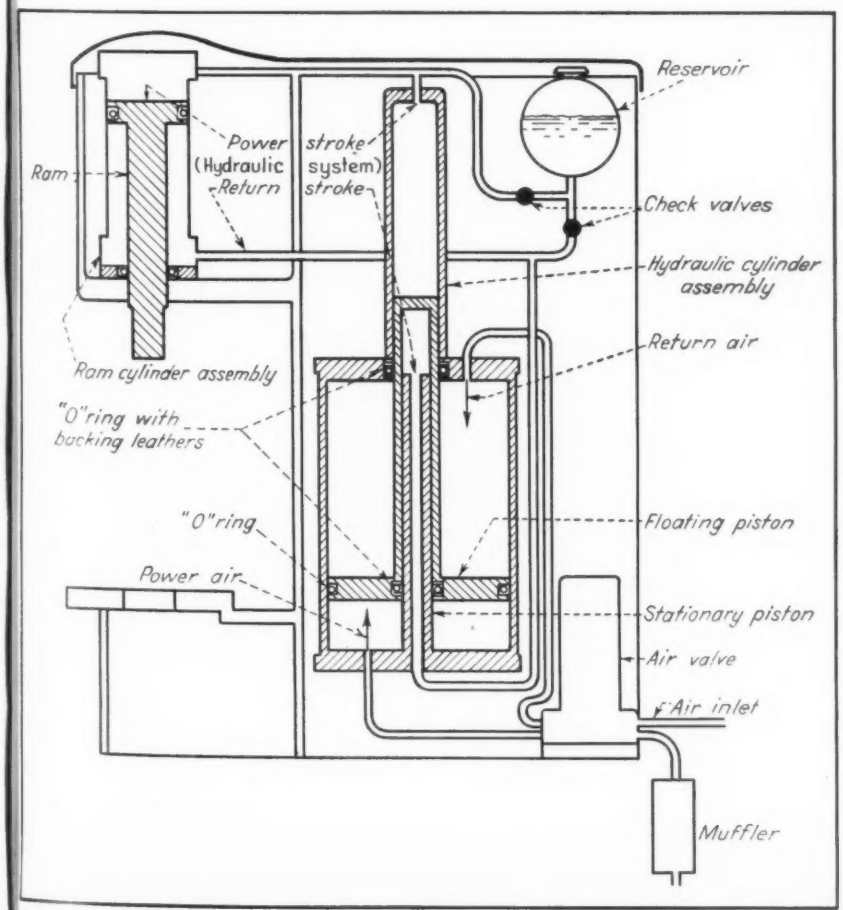

Latch rests on spring
Push plate inserted
For variable pressure operation without impact, a push plate is inserted to lock the ram to the air cylinder piston and the latch spring is placed under the latch to hold it out of action. Ram pressure is now controlled by a regulator in the air line

Double Acting Intensifier for Hydraulic Press

Design of intensifier and ram in Hapco presses prevents changes in volume of hydraulic fluid during operating cycle. This simplifies design of the hydraulic system. Standard models develop 2½ or 5 tons pressure with maximum strokes of 2½ or 5 in. Special models can be built to develop up to 24 tons with a stroke of 1 in. Rubbing surfaces are honed or ground and plated with chromium or cadmium to reduce wear. Rated ram forces are developed with 100 psi air pressure. Integral air pressure regulator permits selection of desired ram force. Optional control arrangements include foot or hand-operated air valve or push button control of solenoid air valve. The manufacturer, Hy-Air Products Co., Jackson, Mich., also supplies floor stands, dial feed tables and a mechanical ram stop for accurately locating bushings or similar parts.



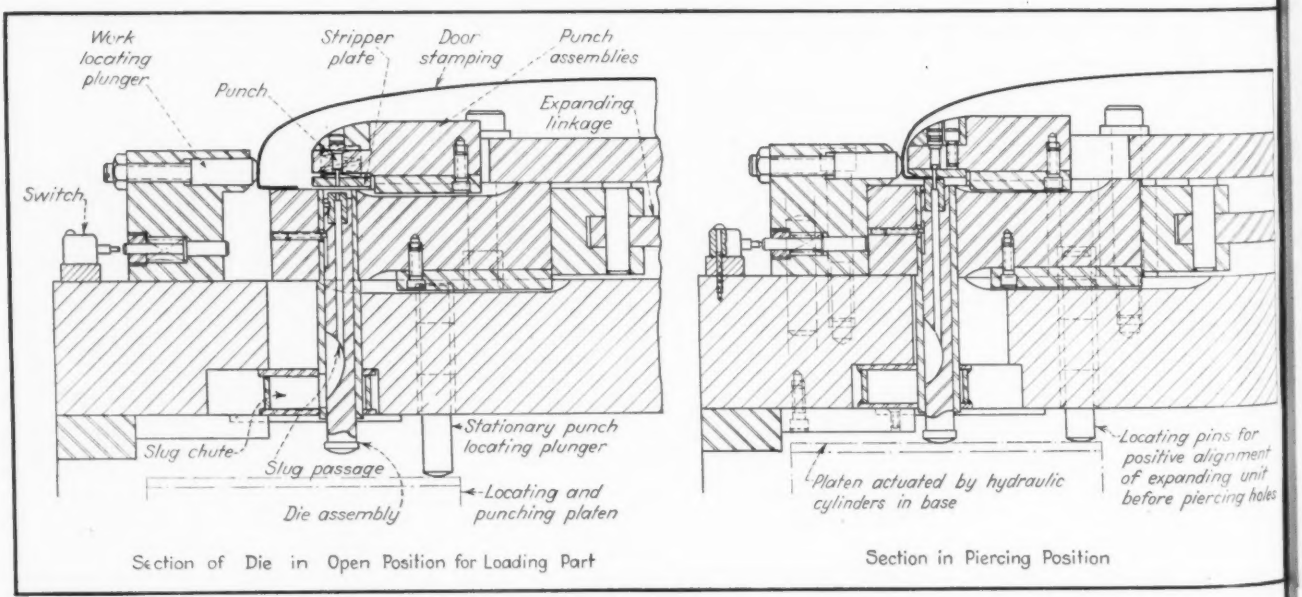
TWO SAFETY PUSHBUTTONS are mounted on base of this 2½ ton, 2 in. stroke press. Air regulator control knob protrudes below pressure gauge. Black knobs on side near top of frame control check valves. Open height of press is 9½ in. Throat is 6 in. deep.



OPERATION OF AIR VALVE applies compressed air to lower side of floating piston. As this piston rises, it displaces oil and forces the ram down. Reversal of air valve at end of stroke applies air pressure to top of floating piston. As piston descends, oil is forced from inner cylinder to lift ram. Volume of hydraulic system does not change during operating cycle because ratio between piston areas of ram equals ratio between corresponding ends of intensifier hydraulic piston. Stroke can be shortened for increased speed and air economy by opening check valves, moving ram by hand to desired top of stroke and closing check valves. Ram will then move between set point and lower end of stroke. Full stroke operating speed varies between 40 and 75 strokes per minute depending upon the pressure and stroke length. Air piston is sealed with an "O" ring, and moving parts of the hydraulic system are sealed with "O" rings and backing leathers.

Movable Units Punch Four Internal Flanges

Movable punch assemblies expand to pierce 55 holes in 4 internal flanges of refrigerator door stampings. Largest stamping accommodated is 8 cu. ft. refrigerator door. Change over to other sizes takes about 1 hr. Cycle is completed automatically in 7 sec after operator places stamping in machine and presses switches. The Vulcan Tool Co., Dayton, Ohio, developed this unit to replace 4 punch presses previously used for the operation.

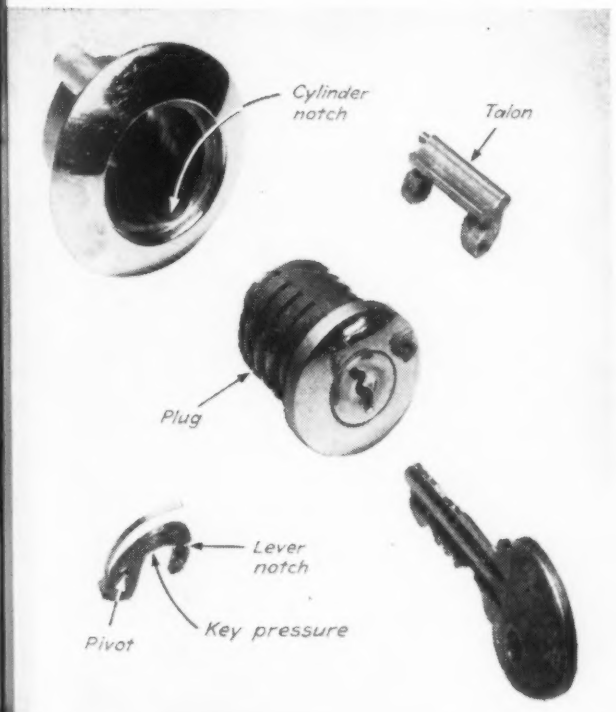


A SERIES of locating plungers position the stamping while a hydraulic cylinder expands 4 punch assemblies inside the flanged edges. When expanded, these assemblies actuate switches, applying oil pressure to 4 vertical cylinders in the machine base. These cylinders raise 4 platens until punch locating plungers enter holes in the punch assemblies. When in position, these plungers close a second set of switches (not shown), applying pressure to 4 more verti cylinders. Latter cylinders raise the platens further to li the die assemblies which force the stamping over fix punches. Platens then retract and spring-actuated plat strip the stamping off the punches. Slugs drop into slu chutes and are ejected by air blasts. Retraction of punc assemblies permits removal of the stamping.

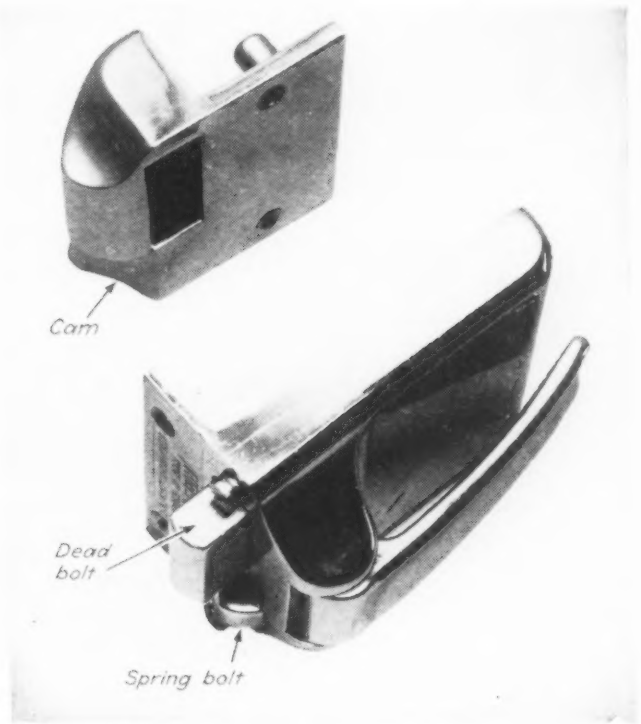
Automatic Deadlock for Maximum Security

Analysis of common burglary methods formed the design basis of the RA 71 automatic deadlock. Details of staple and lock provide strength equal to that of door and frame. Each purchaser has individual key design duplicated only by the maker to prevent unauthorized copies. Brass forgings are used for strength members and zinc base die castings for precision parts. Manufacturer is Ingersoll Locks, Ltd., South Ruslip, Middlesex, England.

ECCENTRIC HOLE causes key to hang at an angle from others for identification in the dark. Lugs on cylinder engage door to prevent forcible rotation of cylinder assembly. Cylindrical stud on forged brass staple is recessed into door jamb. Stud is designed to resist over 4,500 b, a force which will split most door frames, to resist attempts to "jimmy" the door.



WHEN CORRECT KEY has been inserted full depth, key pressure rotates levers about pivots until notches in all 10 levers are aligned. Talon then retreats into plug and clears cylinder notch. This allows plug to rotate and release lock. Levers have 4 possible notch positions, giving approximately 1,050,000 different combinations for each shape of key blank.



WHEN DOOR IS CLOSED, cam forces spring bolt back into lock. This compresses internal spring which projects dead bolt into recess in staple. To open door, deadbolt is retracted by using key to release and rotate cylinder plug or by pulling inside handle. After closing door, inner handle can be locked by use of key. This prevents entry by breaking glass in door and reaching in to actuate handle.

Fig. 1—Typical visual control board showing horizontal and vertical tape pegs. Job order cards at left serve as reference.

Engineering Scheduling and Control

Discussion of scheduling and control fundamentals. Use of visual control board.

GRAYSON D. KIRTLAND
Wassell Organization, Inc.

MOST CHIEF ENGINEERS or administrative engineers will agree that all engineering projects must be scheduled and controlled. But the big questions are how much scheduling and control, and what kind.

The chief engineer of a small group usually keeps his schedules and control procedure in his head, while the chief engineer of a large engineering staff may need an elaborate system of paperwork and several administrative assistants to help him. In between, some responsible engineers work from their heads when they should be using a formal control system, and others who go too far in the other direction.

Anyone who reflects on the subject will come to the conclusion that scheduling and control should be formalized only to the extent necessary to get the greatest benefit from their use. Overworked controls hamper the efficient administrator and underworked controls are a sign of inefficient administration.

Scheduling and control comprise the following steps:

1. Setting up a production schedule for engineering that ties in with overall company schedules.

2. Setting up controls so that the progress of each phase of each project is apparent at all times.

3. Setting up a clean-cut, responsible follow-up system so that bottlenecks, slow-downs and other delays, which throw projects off schedule, can be avoided, eliminated or mitigated.

Just enough scheduling and control serves two purposes: (1) It improves engineering department operations and, (2) it enables top management, sales, advertising and production to keep tabs on engineering, whom they are frequently inclined to regard as the bad boys of the organization.

Just what is enough control? Defined loosely it is control to a degree which enables the chief engineer or other responsible head to have, at his finger tips, the whole story about every significant phase of the engineering operations. But it does not follow that

schedules and control procedures should be more elaborate for a large engineering department than a small one. Rather it is related to the number of specific details that the engineering administrator must be responsible for. For example, it is often easier to control a large number of men working on one design project than a smaller number working on a large number of different projects. A man in charge of a large department designing a new printing press, for example, has possibly an easier job, from a control standpoint, than a man in charge of a smaller group designing a large number of portable powered tools. The first man knows that when he assigns a man to a job, he will be on that job or a related job to the end of the project. He has one group working on the press frame, another on rolls and feeds, another on controls, etc. For proper control he has only to check the group leaders of the various groups to keep tabs on their progress. Assuming the project lasts five months, he need make only about six individual checks a week during the period the project is scheduled. He can easily retain a mental picture of the progress of the project and can keep clearly delineated, the progress of the individual groups.

But take the chief engineer of the portable tools group. He has a number of individual new design projects in work. He also has a number of model modifications in work. A man he assigns to one operation might be able to finish all the necessary details in a two-day period. If he does not check constantly, the designer or draftsman is likely to spend three days on the job requiring only two. One day more does not seem serious, but the sum of these small increments of time can add up to serious losses. The head of this department, then, has no choice but to check constantly in person, to be sure he knows what is going on, or to set up a schedule and control system, which will allow him to see the status of all his projects at a glance.

The supreme test, then, for any system is to ask this question: "Do I know what is going on in my engineering department, and can I supply significant project progress information without hesitation to anyone who asks for it."

Scheduling

Scheduling any operation in the engineering department comprises the selection of a group or a person to undertake an operation and allotting hours to complete the job. Basically this is all there is to overall scheduling or to group scheduling. But the statement is about as practical as saying that all one has to do to cross a river is to build a bridge and walk over it. Making up a schedule can be a difficult job, the quality of which can make or break all subsequent attempts at control. However, an honest schedule is a must.

There are two kinds or schedules. A loose, flexible schedule applies to projects or jobs for which engineering has no previous performance data. For example, during the war many engineering groups were called upon to design equipment not immediately identified with the company's products. Nash-Kelvinator switched from appliances to flying boats, General Motors to tanks, and many other companies to similar, unrelated products. Under these conditions, the chief engineers had to set up bogeys or target dates. These dates were arrived at by consultation with the project men and representatives of other departments. At the end, or even during any one phase of the project, the progress was checked. If the target dates could not be met, they were shifted; but not until it was clear that by changing men, making certain design decisions, or adding men, the dates could not be met.

In cases like these, the best way to set up a schedule is to place some responsibility on the group leaders. During preliminary design conferences, each man has the opportunity to estimate how long it will take him to turn out his work with a given number of men and the required facilities. Possibly his estimate can be cropped to satisfy other extraneous considerations. But in the final analysis he has placed himself on record and is committed to a specific performance. If, later it turns out that his estimate is optimistic, as it sometimes is, the schedule can be readjusted. But usually when a project has been broken down to fundamental operations, experienced group leaders can estimate quite accurately. A group leader in charge of transmissions for trucks, for example, can estimate the time required to design a tank transmission with fair accuracy. He is familiar with certain design aspects of the projects and has a clear conception of design procedure.

The other kind of schedule, the tight, inflexible schedule, works only if performance data exists, gathered from previous jobs involving the same or substantially similar project. Even then, factors such as changes in personnel, experience level, engineering budget and new design features must be considered in setting up the new schedule. As an example, a consulting engineering company designed a number of industrial standby engine-generator sets. After the last design was finished, the group disbanded, some going into other groups, some leaving the company. Several months later the company was given the job of designing another unit for the same client. Performance data were available, but the men were not. As a result, the new schedule chosen was not that for last previous schedule, but with the performance data for the very first design handled. The results showed that the chief engineer's choice of schedule was substantially correct.

The test for schedules then is to ask: "Do I have enough performance data to set up a tight schedule, or will it be more realistic to set up a bogey schedule and revise it as I go along?" Any responsible engineer familiar with his own circumstances can decide without hesitation.

Control

Assuming that all projects in an engineering department are underway and have been scheduled, the next thing is to keep everything on the track and running smoothly.

The purpose of any control system is to enable the chief engineer or group leader to tell quickly whether any phase of the operation is on schedule, behind or ahead of schedule. As discussed before, the administrator can carry the information around in his head; or if there are too many details to remember, he can set up a formal production control systems, which may be rudimentary or more developed, depending on the number of control factors involved.

A visual control board can be used to good advantage if there are many points to check in the process of maintaining control. This board is the apex of a paperwork production control system and sums up all production data. The department head has, in the board, a visual record of the progress on all projects, what ones are off schedule and whether anything is being done to get them back on schedule.

A picture of one such control board is shown in Fig. 1. Physically the board is a grid of punched holes into which small pegs can be inserted. Some of the pegs are attached to elastic tapes that run under the left hand panel covering this portion of the board. The pegs and tapes can be used to set up horizontal lines on the board. Other pegs connected to tapes can be inserted in the board to make vertical lines. In addition, individual pegs can be inserted any place on the board to

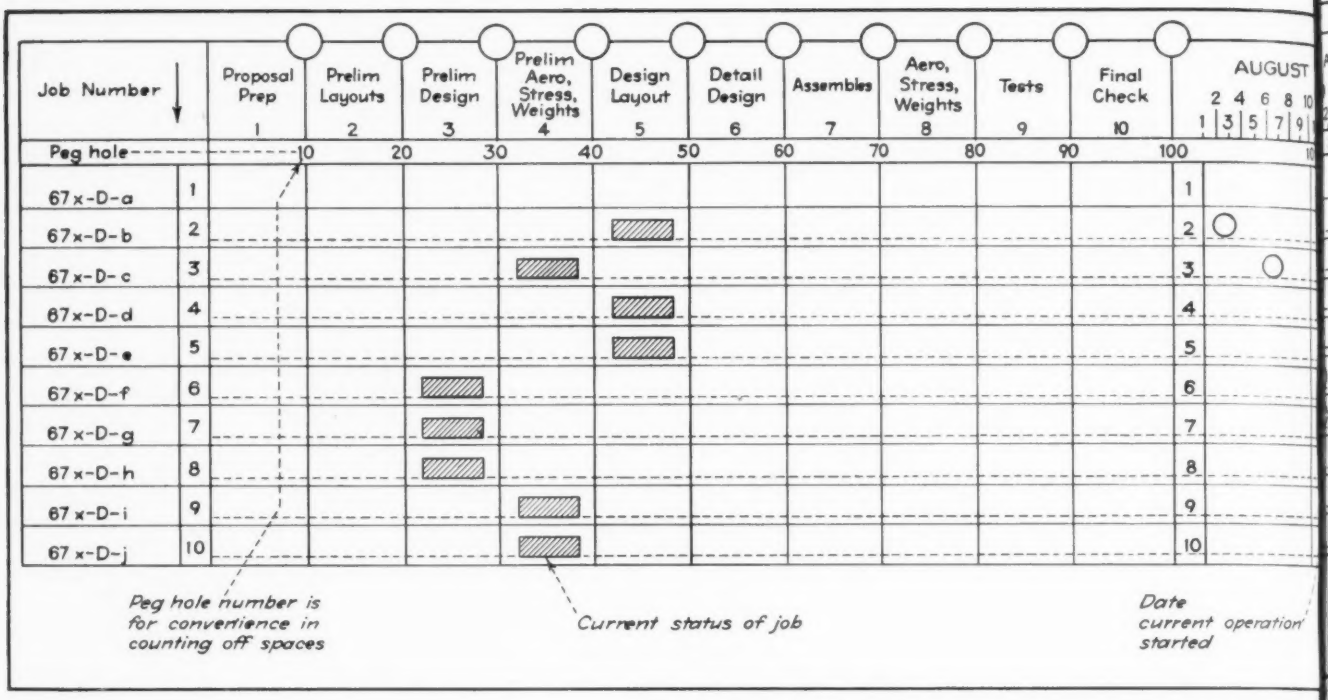


Fig. 2—Section of visual control board showing scheduling and contr

record specific information. The board shown is called the Produc-Trol Board by the Wassell Organization who manufactures it.

Scheduling and Controlling a Project

For discussion purposes, we can assume a hypothetical aircraft development design project. The engineering groups working on the project and some of their jobs follow. The number of the project is 67X.

Engineering Group	Jobs	Job Number
Aerodynamics	Proposal preparation	67x-A-a
	Wind tunnel model design	67x-A-b
	Wind tunnel tests	67x-A-c
	Wing, tail, fuselage configurations	67x-A-d
	Control surfaces	67x-A-e
	Special studies	67x-A-f
Weights	Proposal preparation	67x-W-a
	Weight and balance	67x-W-b
	Mass balance studies, etc.	67x-W-c
Design	Proposal preparation	67x-D-a
	Wing	67x-D-b
	Fuselage	67x-D-c
	Landing gear	67x-D-d
	Power plant	67x-D-e
	Tail	67x-D-f
	Communications	67x-D-g
	Armament	67x-D-h
	Controls	67x-D-i
	Fixed equipment	67x-D-j
Structures	Wing, fuselage, tail, landing gear, power plant, etc.	etc.
Test	Static test, vibration, flutter and flight test	etc.

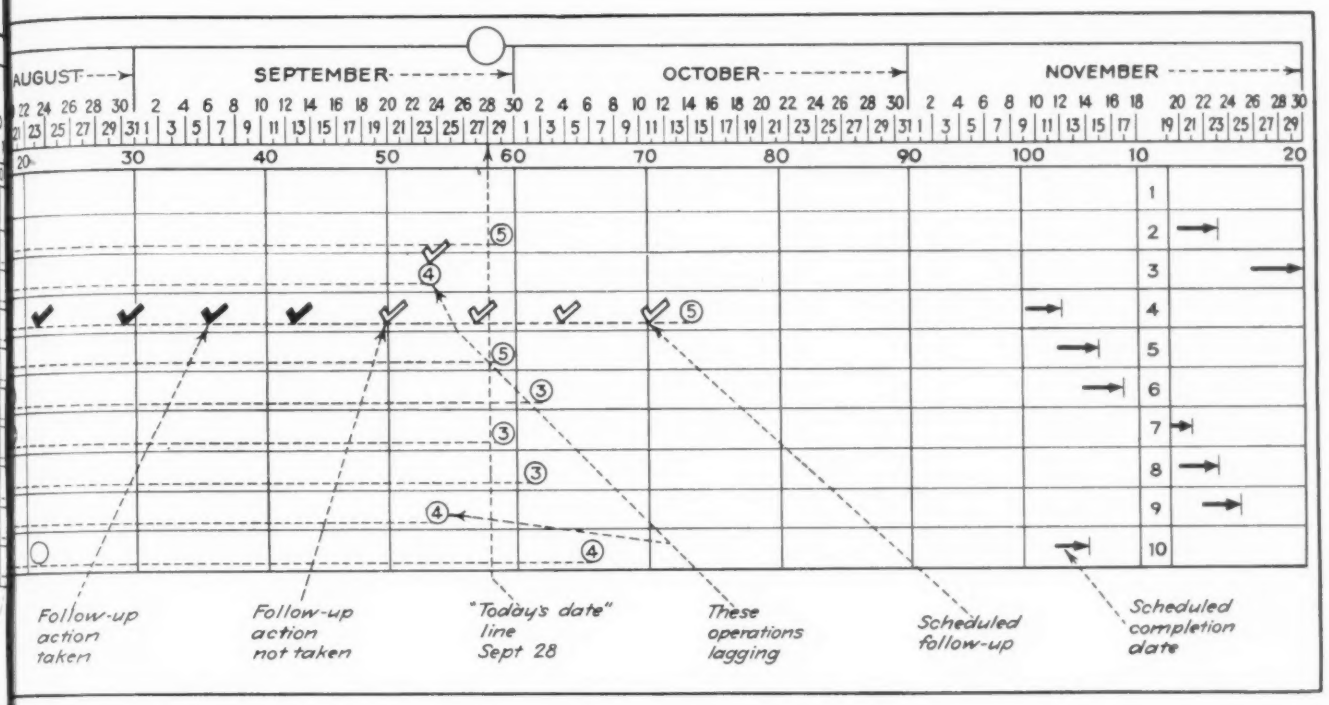
From previous designs, we can assume also that sufficient performance data is available to schedule each group. This includes specifying the number of men working on the project, the time allowed for each operation, and the starting and finishing dates. This is a big job, but not particularly difficult provided the scheduling group uses the performance data available and avoids wild guesses. Performance data may be based on pounds of structure per engineering man-hour, square feet of drawing per man-hour, number of parts per man-hour, or any other reliable index that has been found to work. Each company develops its own units of performance to measure man-hour output. It is sufficient to say that there are few companies who cannot work up some reliable performance data.

Returning to the aircraft project, the next step is to post the schedule on the control board. In Fig. 2 is shown the control board setup for one group only, the design group. The rest of the board setup for other groups is the same except that the vertical column headings, which break the jobs down to successive operations, will be different. On the sample board shown all jobs have started before August 1, hence no starting peg locations are shown. The scheduled finish dates, however, for each job (such as 67X-D-d) are posted using pegs shaped as horizontal arrows. In posting the overall schedule for each job on the board, detailed information relating to that job is entered on a job card (see Fig. 3). This card is put in the cardex on the left side of the board and identifies each horizontal line on the board. The cards overlap so that the last line only is seen. Listed on the card is the job, the operations involved, the scheduled starting and finish dates, and other information needed for job analysis and future projects.

Next, the schedules for the current operations (for example, Design Layout on job 67X-D-d) for each job are posted. As shown, round pegs are used to show the starting and finishing dates. Note that the operation schedule dates shown at any one time apply only to the operation indicated by the rectangular peg in the current status section of the board.

The next feature is the "today's date" line, which is advanced day by day. If, on any one day, the "today's date" line passes the round peg indicating when the current operation of a job is scheduled to be finished, the indication is that the operation is lagging behind schedule. If this happens, a follow-up peg can be posted to indicate that action must be taken on the operation that has fallen behind. One color follow-up peg can be used to call for follow-up action and another color follow-up peg to show that action has been taken.

If, on the other hand, an operation is finished before the scheduled date, the schedule clerk removes the scheduled dates for that operation and posts the scheduled dates for the next suc-



formation for a design group working on an aircraft project.

cessive operation, thus keeping the board up to date.

Occasionally single operations on a job are scheduled for several months. Obviously, if the board only indicated the fact that "today's date" line had passed the scheduled finish date of the project, without indicating the actual status of the operation, follow-up action might be a case of "too little and too late." What is needed for operations that run for months, is scheduled follow-ups at regular intervals to see that the job is holding to schedule. For example, if a schedule follow-up is made when 25 percent of the total man-hours for the operation have been used up, and the best estimate is that the operation is only 15 percent complete, something can be done to pull it back on schedule before much harm is done. But if we wait until "today's date" line crosses the finish date peg for the operation, it might be found that the job is actually only 50 percent complete, and then it is too late to do anything to avoid a sorry performance.

The advantages of this type of control board in engineering scheduling and control is that it shows many more details of control than any one chief engineer can visualize at one time. Second, it shows the status of each job by visual indication. Third, it shows which operations are lagging, whether follow-up action is scheduled, and whether such action has actually been undertaken.

As mentioned previously, the control board is the end product of a system of paperwork. To set a schedule and control system of this sort in operation, the scheduling and control group responsible for maintaining the board, must prepare individual schedules for each engineering group, furnish operation status forms, keep time records of man-hours used on all operations, fill out follow-up reports and keep records of each individual's performance. It is impossible to outline the procedure for making up these forms because each company has different requirements. However, they should be simple and should not ask for more information than is necessary.

In using a visual control board system as described or any other system, there are several points to keep in mind. First, it is only an aid to intelligent thought and action, not a substitute. The board itself performs only a clerking job and can at best be only an aid to the engineering administrator. Second, unless there is good team work between the engineering groups, the scheduling and control staff, and other groups, it is better to dispense with it entirely, and save money and time. Third, the system should never be allowed to become so fussy and unwieldly that those in charge begin to have the feeling that they have created a Frankenstein.

JOB NO. 67x-D-C | JOB NAME Fuselage Design | QUANTITY | DESCRIPTION

REC'D H. Warren SCHED BY E. Scott STARTED

DESCRIPTION OF ORDER:

Fuselage Details and Assemblies

SPECIAL INSTRUCTIONS:

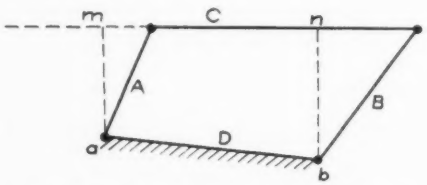
OPERATIONS OR DEPARTMENTS	1ST SCHEDULED DATE	REVISED SCHEDULE	ACTUAL COMPLETION DATE	EARLY	LATE	HOURS ALLOTTED	HOURS USED	REMARKS
#1 Proposal Preparation								
2 Prelim Layouts								
3 Prelim Design								
4 Prelim Aero, Stress, Wts								
5 Design Layout								
6 Detail Design								
7 Assemblies								
8 Aero, Stress, Weights, Check								
9 Tests								
10 Final Check								
#1								
2								
3								

LINE # | ORDER NO. | ORDER NAME | QUANTITY | DESCRIPTION | BOARD #

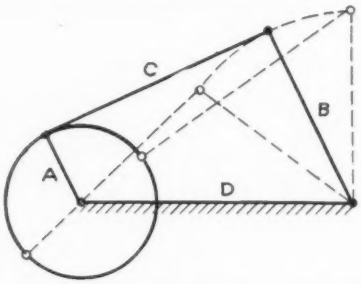
Fig. 3—Job order card used for entering job on board and for permanent record.

Four-Bar Linkages and Typica

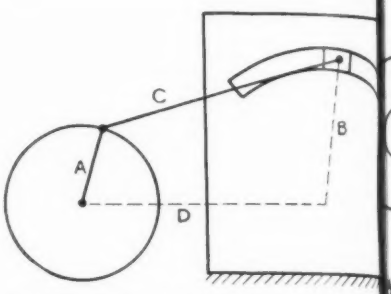
All mechanisms can be broken down into equivalent four-bar linkages. They can



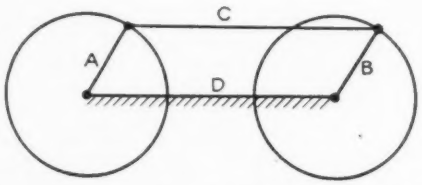
FOUR-BAR LINKAGE—Two cranks, a connecting rod and a line between the fixed centers of the cranks make up the basic four-bar linkage. Cranks can rotated if *A* is smaller than *B* or *C* or *D*. Link motion can be predicted.



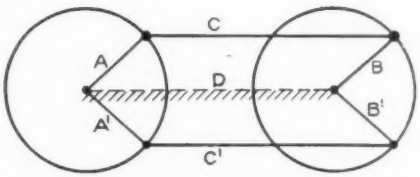
CRANK AND ROCKER — Following relations must hold for operation: $A+B+C>D$; $A+D+B>C$; $A+C-B<D$, and $C-A+B>D$.



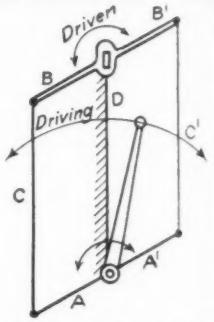
FOUR-BAR LINK WITH SLID MEMBER—One crank replaced by cir slot with effective crank distance of B



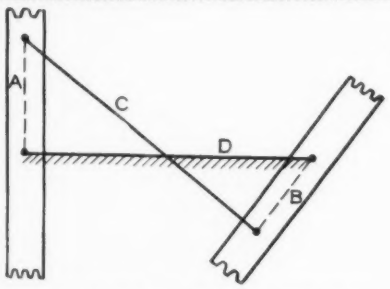
PARALLEL CRANK FOUR-BAR—Both cranks of the parallel crank four-bar linkage always turn at the same angular speed but they have two positions where the crank cannot be effective. They are used on locomotive drivers.



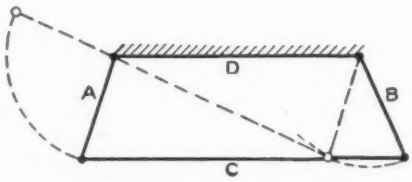
DOUBLE PARALLEL CRANK—This mechanism avoids dead center position by having two sets of cranks at 90 deg advancement. Connecting rods are always parallel. Sometimes used on driving wheels of locomotives.



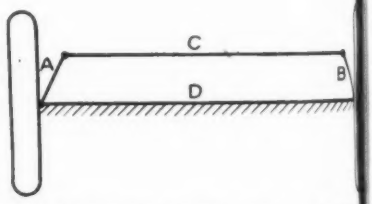
PARALLEL CRANKS—Stea control linkage assures equ valve openings.



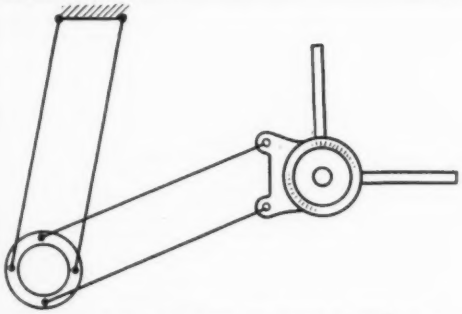
NON-PARALLEL EQUAL CRANK—The centrodes are formed as gears for passing dead center and can replace ellipticals.



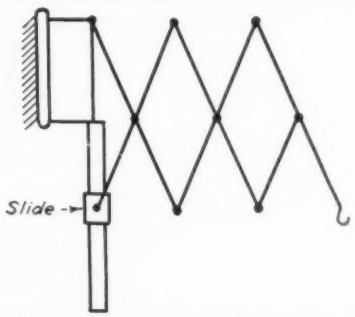
SLOW MOTION LINK—As crank *A* is rotated upward it imparts motion to crank *B*. When *A* reaches dead center position, the angular velocity of crank *B* decreases to zero. This mechanism is used on the Corliss valve.



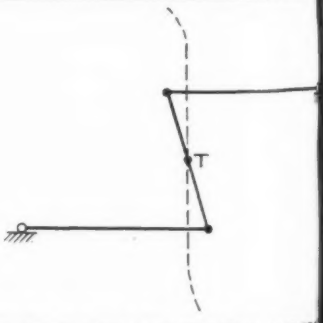
TRAPAZOIDAL LINKAGE—This link is not used for complete rotation but be used for special control. Inside m through larger angle than outside w normals intersecting on extension of axle in cars.



DOUBLE PARALLEL CRANK MECHANISM—This mechanism forms the basis for the universal drafting machine.



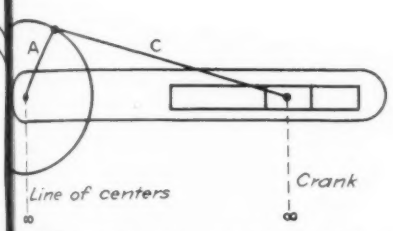
ISOSCELES DRAG LINKS—"Lazy-Tong" device made of several isosceles links; used for movable lamp support.



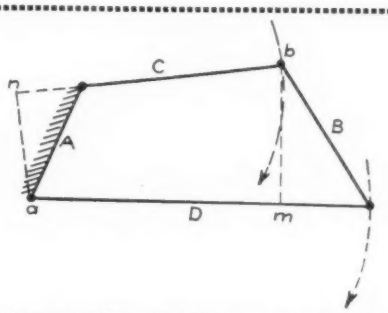
WATT'S STRAIGHT-LINE MECH ISM—Point T describes line perpen lar to parallel position of cranks.

ndustrial Applications

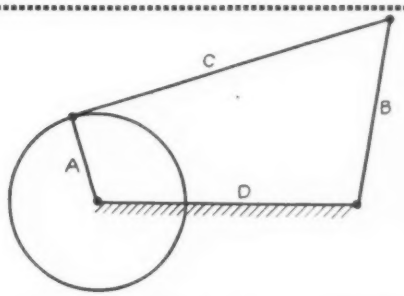
ught of as the basic mechanism and are useful in many mechanical operations.



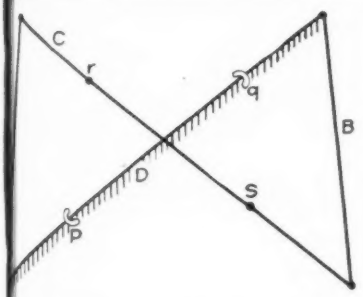
IGHT SLIDING LINK—This is the in which a slide is usually used to re- a link. The line of centers and the *B* are both of infinite length.



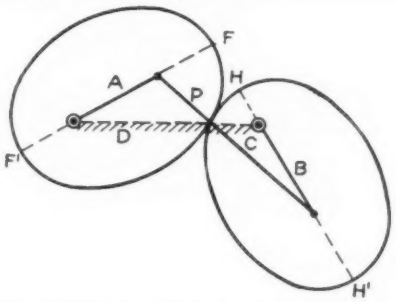
DRAG LINK—This linkage used as the drive for slotter machines. For complete rotation: $B>A+D-C$ and $B<D+C-A$.



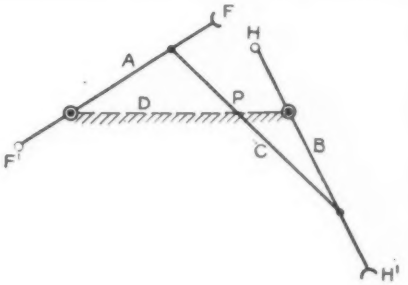
ROTATING CRANK MECHANISM—This linkage is frequently used to change a rotary motion to swinging movement.



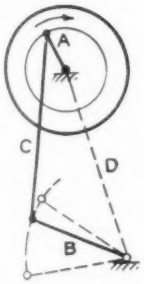
-PARALLEL EQUAL CRANK—If *A* has uniform angular speed, *B* will



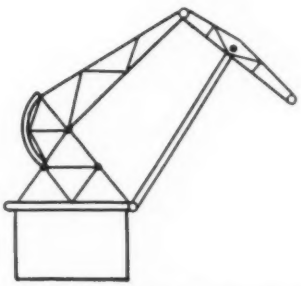
ELLIPTICAL GEARS—They produce same motion as non-parallel equal cranks.



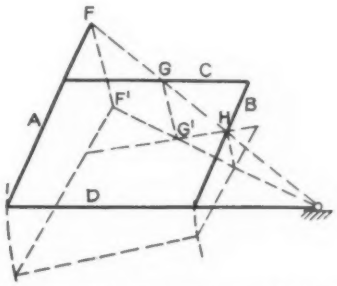
NON-PARALLEL EQUAL CRANK—Same as first but with crossover points on link ends.



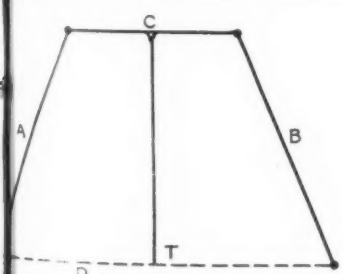
ADLE DRIVE—This four-bar ge is used in driving grind- ls and sewing machines.



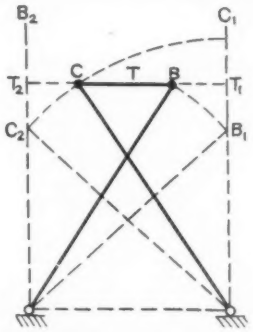
DOUBLE LEVER MECHANISM—Slewing crane can move load in horizontal direction by using D-shaped portion of top curve.



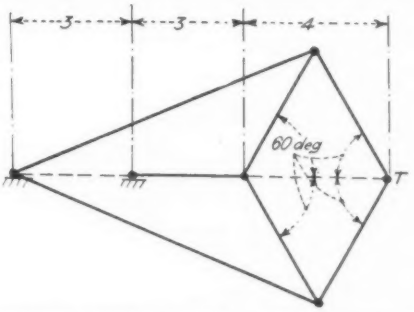
PANTOGRAPH—The pantograph is a parallelogram in which lines through *F*, *G* and *H* must always intersect at a common point.



ERT'S STRAIGHT-LINE MECH- SM—The lengths of cranks *A* and ould not be less than 0.6 *D*; *C* is half *D*.



TCHEBICHEFF'S—Links made in proportion: $AB=CD=20$, $AD=16$, $BC=8$.



PEUCELLIER'S CELL — When proportioned as shown, the tracing point *T* forms a straight line perpendicular to the axis.

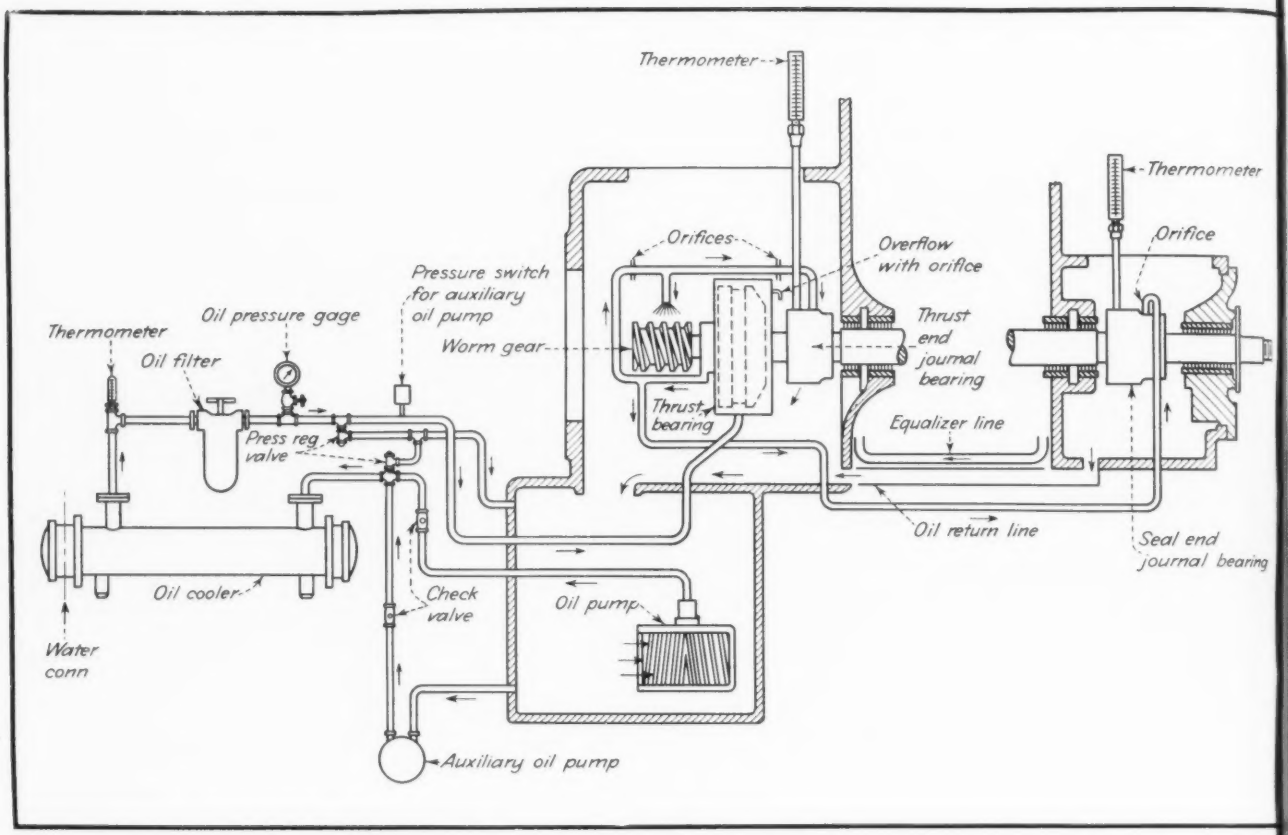


Fig. 1—Lubrication system for a centrifugal air compressor, typical of installations for high-speed, heavy duty machinery. The design of a system such as this is covered in detail in t text, including the various flow rates pipe sizes requir

Bearings and Lubrication fo Hi

Conservative design of journal bearings and lubrication systems for high-speed, heavy duty machinery of long life expectancy.

R. W. McLAUGHLIN
Director of Development, Carrier Corporation

TURBINES, two-pole generators, large gear sets, heavy motors, centrifugal compressors and other heavy high-speed machines have bearing requirements that are similar in many respects. All these machines run at speeds from 3,000 to 20,000 rpm. Used in power plants or industrial installations, they must run continuously except for possibly an annual shutdown for inspection and repairs. The life expectancy of such equipment is fifteen, twenty, or even thirty years. Each machine is more or less a tailor-made design. Only a few of any specific design are produced, and it is uneconomical to build an experimental test model. Hence, the machine must be somewhat over-designed to make certain it will operate satisfactorily with not more than a few simple adjustments at the start.

Usually it is the bearings and associated elements of such machines that are most critical with respect to durability. Hence, unit bearing pressures must be conservative, bearing clearances must be ample, size of lubricating pipes and associated devices must be more than sufficient, oil supply must be overabundant and all other allowances must be correspondingly liberal if satisfactory life is to be obtained.

All machines of the class under consideration can be grouped in so far as power requirements are concerned into; (1) Stiff-shaft machines versus flexible-shaft machines, (2) low bearing surface speed versus high bearing surface speed machines. The first of these considerations affects the bearing proportions; the second the lubrication provisions. Stiff-shaft machines are those having a sufficiently large diameter shaft so that the critical speed is at least twenty to twenty-five percent above the maximum operating speed. Flexible-shaft machines are those which have critical shaft spee below the operating speed.

In stiff-shaft machines, the diame of the shaft is so large that the jour must be turned down to take a bear of reasonable size. However, it usually impractical to turn shaft jo nals down to diameters that result reasonably high unit bearing pressu Hence unit bearing pressures are re tively low, ranging from 35 to 60 for most machines. The maximum rarely more than 100 psi. Ususally bearings are square, that is, th length is equal to their diameter. T proportion usually gives sufficient be ing area and also represents the mi mum practical length for a heavy t bearing. Square bearings also per shorter center-to-center distance tween bearings, thereby resulting i more compact machine.

If the journal is designed with diameter appreciably greater than n essary, the surface speed of the be ing and the horsepower friction l is correspondingly greater. Howev when journal diameter becomes m less than half the diameter of the m shaft, the proportions begin to l

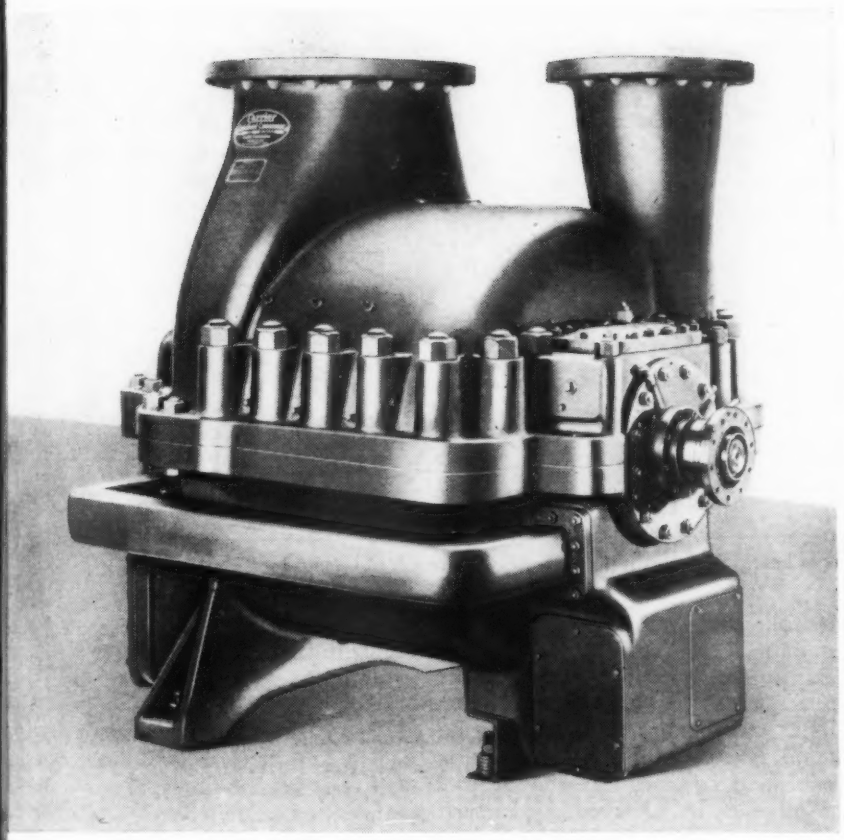


Fig. 2—High-speed, heavy-duty machinery design must be conservative to insure long, trouble-free operation. Shown above is a centrifugal compressor.

for High-Speed Machinery

ridiculous. Also the stresses in the journal become higher than desired.

As an example of bearing calculations; assume a centrifugal compressor with a rotor weighing 700 lb, running at 8,000 rpm. Also assume an allowable unit bearing pressure of 40 psi. If two square bearings of the same size are used to support the rotor shaft, the required bearing area is 17.5 sq. in. Hence each bearing has a projected area of 8.75 sq. in. A 3 by 3 in. bearing is adequate. And the relative rubbing speed of the bearing and journal is $3 \times \pi \times 8000/720$ or 105 fps approximately.

However, the rotor shaft must transmit the torque required to drive the machine. Hence the journal diameter chosen must be stress checked to find out if the shear and torsion stresses developed are safe. Allowing for stress concentrations due to discontinuity in shaft diameter and to the keyway cut in the journal extension to accommodate the motor coupling, the shear stresses developed should not exceed 6,000 psi for SAE 1040 steel or 8,000 psi for high strength alloy steels.

The cold clearance between journal and bearing should be from 0.0015 to 0.002 in. per in. of journal diameter. The bearing material most commonly used is a good grade of tin base babbitt, $\frac{1}{32}$ in. or slightly more in thickness. Lately some excellent lead base bearing metals have also been developed.

Bearing Lubrication

The probable power loss in the bearings must first be calculated to determine the amount of lubricant required. This is necessary, because the lubricating oil often must remove the heat of friction plus any heat conducted to the bearing from within the machine itself. Because it is virtually impossible to calculate the amount of heat developed by the elements that contribute heat to the bearing with any accuracy, safe and sane procedure is to use the old empirical formula:

$$\text{hp loss} = 1.945 \times 10^{-7} \times D^{2.7} \times L \times N^{1.7} \times T^{-.73} \qquad (1)$$

where

D = bearing, dia, in.
L = length, in.
N = shaft rpm
T = inlet oil temp, deg C

This formula will give larger horsepower losses than generally realized, and is based on an assumed oil rise temperature in the bearing of 30 F. The unit bearing pressure does not appear because the effect of loading on horsepower loss is small as long as oil film lubrication is good. However, a given allowable bearing pressure is actually incorporated in the dimensions D and L appearing in the equation.

To simply calculations, Fig. 3 is given. The horsepower loss of various diameter bearings per in. of length can be obtained directly from the curves. For a 3 in. dia. bearing operating at 8,000 rpm, the curve in Fig. 3 shows a loss of 0.88 hp per in. of length, or 2.64 hp per bearing; or 5.28 hp total for two bearings.

The horsepower loss equation is based on a lubricating oil having a viscosity of 150 Saybolt sec at 100 F. The average specific heat of such an oil is about 0.47 btu per lb; average specific gravity is about 0.9, the weight per gallon being 7.5 lb. Hence the total gallons per minute of lubricating oil required will be

$$\text{gpm} = \frac{33{,}000}{0.47 \times 778 \times 7.5} \times \frac{\text{hp loss}}{\text{temp rise, deg F}} = \frac{12.05 \times \text{hp loss}}{\text{temp rise, deg F}}$$

Allowing a 30 F temperature rise

gpm = 2.1 for two bearings

In machines operating over 400 F, allow an extra 15 or 20 percent oil flow per 100 F above 400 F.

To deliver the oil to the bearings, the lubricating oil pressure commonly used ranges from 10 psi gage pressure on small units to 20 psi on larger units, up to 30 or even 40 psi gage on the largest machine. For the compressor under consideration, which is a moderately small unit, a gage pressure of 15 psi controlled by a spring-loaded relief valve can be used. The pressure switch controlled auxiliary oil pump motor will start if the pressure drops to 11 psi and will stop if the pressure rises to 13 psi.

The oil line from the pump is connected to the bearing line just below the parting line made by the cap. For this 3 × 3 bearing, $\frac{1}{16} \times \frac{1}{8}$ in. deep horizontal chamfered grooves are cut in the bearing at the junction of the cap and body of the bearing, joined by a radial groove over the top of the bearing. These grooves stop at least $\frac{1}{8}$ in. from the bearing ends. If, however, the temperature rise of the bearing is too high (greater than 30 to 50 deg. F), the groove on the

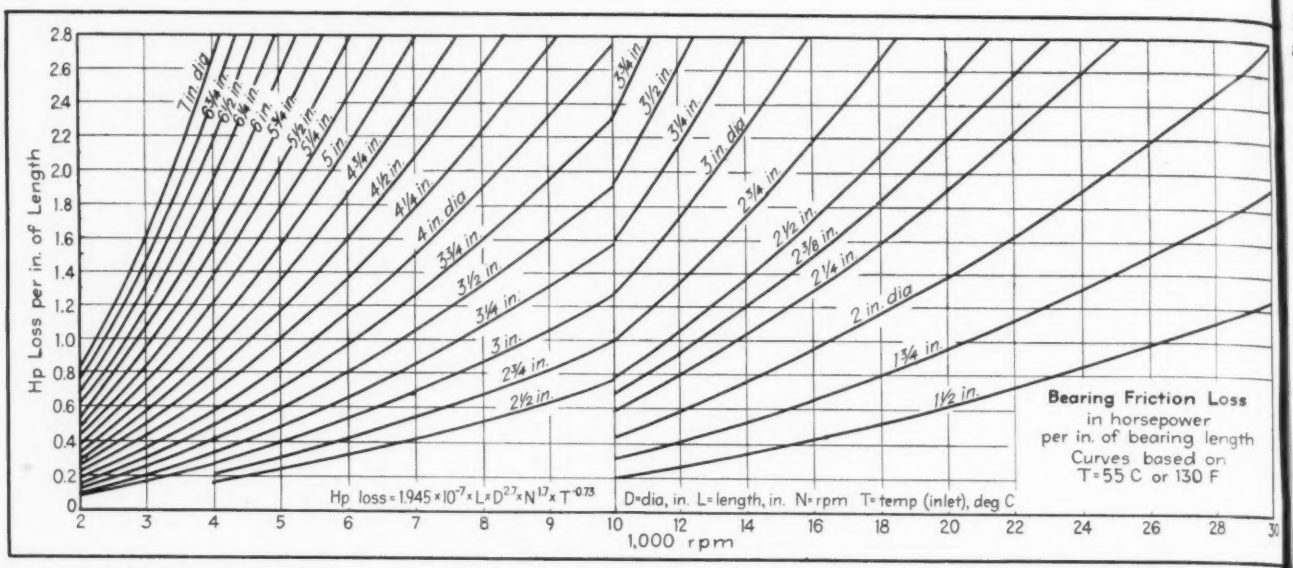


Fig. 3—Friction horsepower-loss curves for sleeve bearings. About 0.4 gpm of oil is required per hp loss for 30 F temperature rise

side opposite the feed can be notched out to the end of the bearing to permit greater flow of oil over the bearing.

If it is desired to meter oil to the bearing by making it pass through an orifice, the size of the orifice desired can be calculated from:

$$G = 40\,CA\sqrt{\Delta P} \qquad (2)$$

G = oil flow, gpm
C = orifice constant, about 0.70 for a hole drilled in flat plate
A = orifice area sq. in.
ΔP = pressure differential, psi

This equation is for oil of 0.90 sp gr. For water the coefficient changes from 40 to 38. For liquid of any other specific gravity, the coefficient becomes

$$38/\sqrt{\text{sp gr}}$$

Gear Lubrication

Bearing dimensions and lubrication for gear shafts are calculated in the same manner as outlined above. In addition, oil must be furnished to cool the gears. The tooth machine loss is approximately one percent of the horsepower transmitted, or 10 hp per 1,000 hp transmitted. Again allowing a 30 deg F temperature rise, the oil required will be 0.4 gpm per horsepower loss or 4 gpm per 1,000 hp transmitted. However, because much of the oil will not contact the teeth if splash or conventional flood lubrication is used, the preferable method is to spray the oil on the teeth as they go into mesh, and allow a twenty-five percent loss at each meshing point. That is, use 5 gpm per 1,000 hp for each meshing point. Double reduction gears require twice as much oil as a single reduction. This is a crude approximation and more accurate gear oil requirements should be used when figures are available.

Common practice is to direct the gear oil sprays into the teeth as they go into mesh. This is practical for gears running up to a pitch velocity around 8,000 or 10,000 fpm, but on higher speed gears, the work done on the oil as it goes through the meshing of the gear becomes excessive because the oil must be squeezed out in such a short period of time. On the highest speed gears, lower gear temperatures and less power losses will be obtained if the spray is directed against the teeth as they come out of mesh. The oil then carries away the heat, which has just been generated, and a sufficient amount of oil is carried around back to the meshing point to assure good lubrication.

Other Lubrication Requirements

In addition to the oil required for cooling bearings on a machine, it is used also for many other purposes. Following is a list of the approximate amounts of oil required for accessories on machines running from about 500 to 5,000 hp. Obviously, the smaller machines could use less oil, but where metering orifices or clearances are providede to control the flow, it is impractical to go below certain minimum dimensions. Orifices much less than $\frac{3}{16}$ in. dia clog with scale or foreign matter occasionally; and in control devices, clearances affecting leakage are a function of machining tolerances and working fits, which have practical minimum limitations.

About 1 gpm is needed for the worm wheel. The main oil pump and auxiliary oil pump will be self-lubricating because the bearings are intimate with the rotors, but an extra 0.5 gpm might be allowed for the low oil pressure protective device and 1.5 gpm for the oil-cooled shaft seal. The total calculated oil requirement for this centrifugal compressor is:

Oil-cooled shaft seal	1.0–2.0 gpm
Low oil pressure safety trip	0.5
Pilot valve and power piston leakage	1.0–2.0
Overspeed oil trip valve	0.5
Trip piston on throttle or non-return valve	0.5
Continuously lubricated coupling	1.5–2.0
Worm and wheel (or gears) driving oil pump	1.0–1.5
Journal bearings	2.1
Thrust bearing	12.4
Worm-wheel	1.0
Low oil pressure trip	0.5
Shaft seals	1.5

Only certain of these accessories are needed on the machine being discussed, namely the journal bearing, thrust bearing, worm wheel, low pressure oil Trip, and shaft seals. The required oil flow to these totals 17.5 gpm, but only the journal and thrust bearings add heat due to friction. The total horsepower loss in these units is 36.3 hp. In selecting pumps, strainers and oil cooler, add 25 percent oil to be sure there will be sufficient oil available to allow for operation at reduced speeds, abnormal operating temperature conditions in the machine, oil loss through worn bearings when the machine is old, and such unforeseen hazards. Therefore, select oil pumps to provide $17.5 \times 1.25 = 21.9$ gpm and a cooler to remove $36.3 \times 1.25 = 45.4$ hp, equivalent to $45 \times 2546 = 115{,}000$ btu per hr. A gear pump of 22 gpm capacity will be used.

Gear oil pump efficiencies vary a great deal, depending upon the quality of workmanship, details of construction, capacities, pressures, etc. With pumps operating at about one-half cavitation speed and pressures from

150 to 200 psig, at the discharge, overall efficiencies (shaft input versus change of energy in the liquid) of 50 to 60 percent are readily obtainable. However, for this pump, operating at a low discharge pressure, the useful work done is small compared with bearing and mechanical losses, and as a consequence, the efficiency will run as low as 30 percent.

The horsepower required to drive such a pump is as follows:

$$hp = \frac{P \times G}{1{,}720 \times e} \qquad (3)$$

P = pressure increase across pump, psi
G = liquid flow, gpm
e = overall pump efficiency
For our example, $P = 15$, $G = 22$, and $e = 0.30$.

$$hp = \frac{15 \times 22}{1{,}720 \times 0.30} = 0.64 \text{ hp}$$

This formula hold regardless of pump proportions or type except that these factors do effect the efficiency.

Accessories

After determining the lubricating oil requirements for this unit, we must add the items of equipment needed to supply the required amount of cool, clean oil to the bearings, etc. We must also provide the operator with means of determining whether everything is working properly, and provide automatic means to prevent the machine from running without adequate lubrication. Following are most of the items required:

1. An oil cooler to remove the heat transmitted from the machine to the oil. The following facts must be known in order to design or purchase a cooler. The numerical values in this list are either based upon our specific example as indicated by parenthesis (), or are established from general good practice. Such items as rate of flow of the cooling water, and the allowable water pressure drop, are subject to local conditions, of course.

A. Rate of oil flow, gpm = (22).

B. Allowable oil pressure drop through the cooler = about 5 psi, max.

C. Oil viscosity. For high speed equipment this should be a light oil of about 150 SSU at 100 F, or for a geared unit, heavy medium grade with about 280 SSU at 100 F. Fig. 4 gives the oil viscosities for popular grades.

D. Temperature of oil entering and leaving the cooler and heat removal rate. Normally these figures are specified as 150 F and 120 F respectively, allowing for a 30 F temperature rise in the bearing. Actually, since we have allowed an oil flow rate of 25 percent in excess of requirements, this will give a somewhat greater value than will be obtained if we calculate heat loss from 42.42 × horsepower loss. However, it is a safe value to use since it will allow some margin for removal of heat which may be picked up from a hot machine by the lubricating oil. Heat removal, for example, = (22 gpm) × (7.5 lb/gal) × (60 min/hr) × (30 deg removal) × (0.47 sp heat) = 140,000 btu/hr.

E. Rate of flow of cooling water, gpm. A good average value is about half the rate of oil flow, which will allow less than 30 F temperature rise in the water.

F. Allowable water pressure drop, about 5 psi.

G. Entering temperature of cooling water, also whether fresh or sea water, clean or dirty.

H. Size of tubes, whether removable tube bundle, how cleaned, type and size of oil and water connections. It is obvious that for dirty water some simple means of cleaning will be required.

2. In order to avoid recirculation of foreign material in the oil, a strainer or filter must be provided. This should preferably be of some cleanable type such as a dual basket strainer in which the entire oil flow can be put through one basket while the other is removed for cleaning, or it may be a plate type filter, cleaned by turning a handle. For finer filtering, other types are available.

3. Oil feed and drain lines of ample proportions and rugged construction must be provided to conduct the oil around the circuit. Maximum allowable velocities are about as follows:

A. Screwed or flanged iron pipe pressure lines, 330 ft per min.

B. For short streamlined tube feed lines, about 450 ft per min. These lines must be properly vented and should normally be well sloped so as to run perhaps half full. A vent is needed, particularly in an elbow at the top of a vertical drop because air does not seem to clear itself readily from this sort of arrangement.

The type or quality of oil piping depends on many things. For machines running at temperatures from 600 or 700 F, and above, where there is a hazard of fire if an oil line breaks and leaks on a hot surface, it is customary to use welded steel pipe with high pressure bolted flanges. For low temperature machines, streamlined tubing, compression fittings, etc., are acceptable. Screwed fittings are not popular for most machines of the class we are discussing, unless the unit is very small. For 22 gpm, using welded pipe for the main oil feed line, the size will be 1¼ in. (See Fig. 5.)

4. When an auxiliary oil pump and regulating valve or switch is required, several choices are available. If the main unit is steam-driven, either a steam-driven or motor-driven auxiliary oil pump can be used, either of the reciprocating, centrifugal or positive displacement rotary type, depending on the choice of the user. Steam-driven auxiliary pumps are controlled normally by a pressure operated regulating valve in the steam line, with its diaphragm connected to the oil pressure line. Upon start-up it will run at full speed. As the main pump driven from the main unit shaft increases in speed, building up oil pressure, the regulating valve will gradually slow down the auxiliary pump,

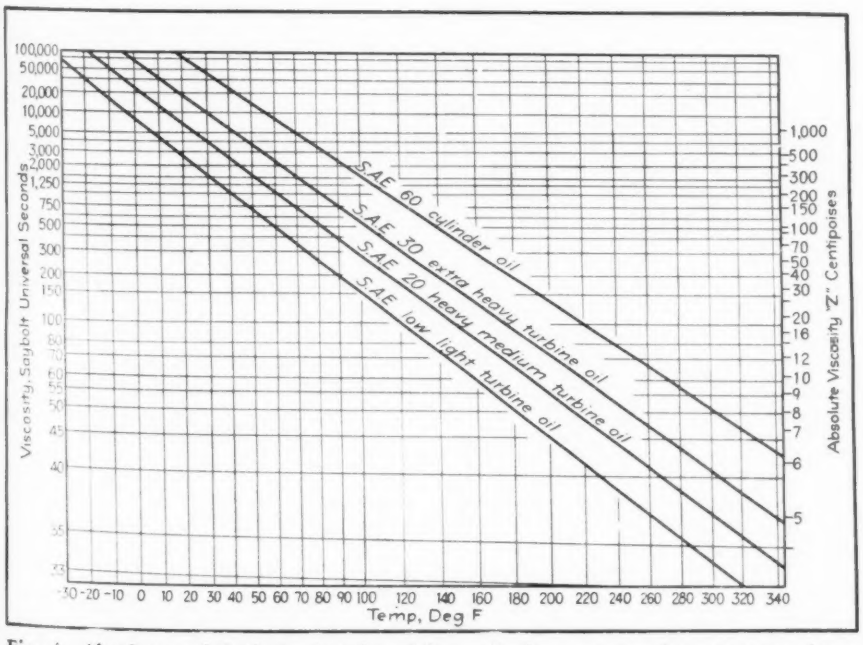


Fig. 4—**Absolute and Saybolt viscosity of four oils for a range of temperature from —30 to 350 deg. F.**

attempting to maintain the pressure constant, but a little less than the normal operating lubricating oil pressure. Thus, before the main unit reaches full speed, the auxiliary pump will be shut down.

With a motor-driven pump operated by a pressure switch, the switch must have considerable lag, or pressure difference, between starting and stopping pressures. During start-up, this type of pump will run at full speed until the main pump has brought the pressure up to a couple of pounds in excess of normal operating pressure, at which point it should cut out. The pressure will suddenly drop several pounds and the switch must not start the pump again at this pressure, or it will be constantly cutting in and out. A motor-driven pump should have a capacity slightly under the normal full speed unit requirements in order that the pressure change will not be too great when this pump starts or stops.

5. A number of little items are required to complete the system. It must have an adjustable automatic relief valve to bypass back to the tank any oil pumped in excess of requirements. Pressure gauges and thermometers for the operators must be located at critical points in the system. It is customary to provide a low oil-pressure safety-trip device, which will automatically shut down the main unit, should the oil pressure fall to a point lower than the safe operating value. The auxiliary oil pump should start up and supply the oil, but the safety trip also is desirable on large units.

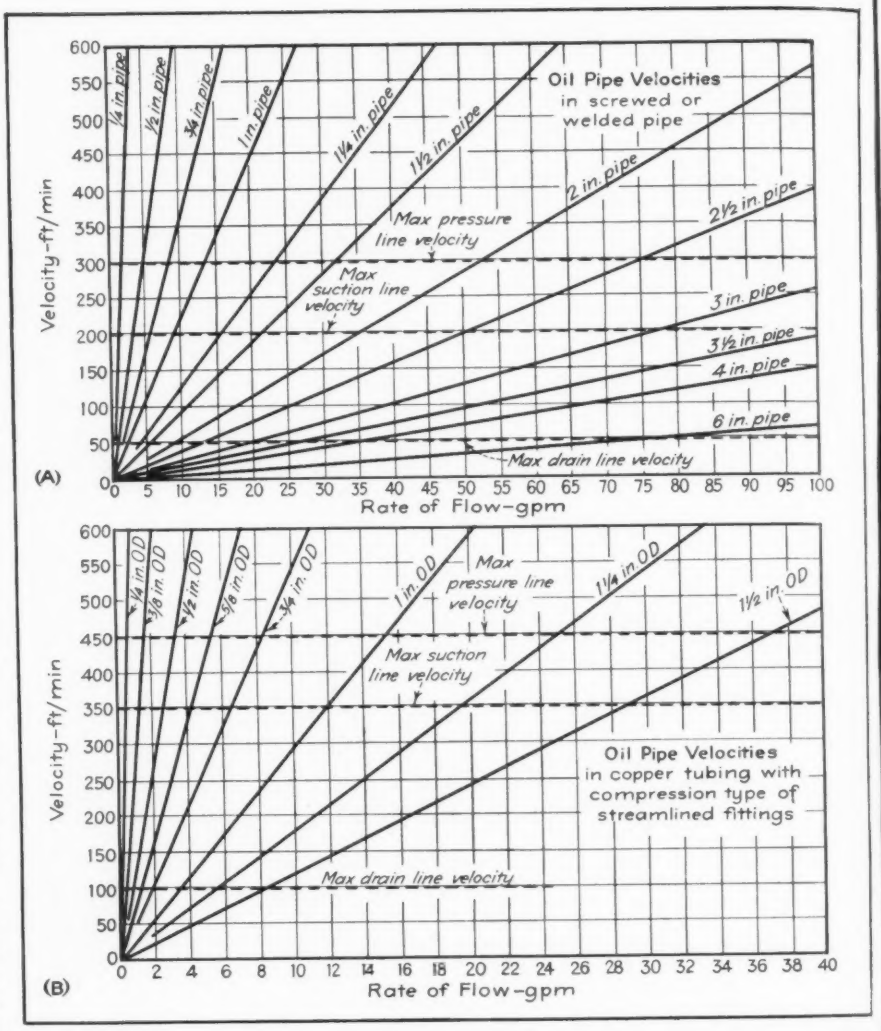


Fig. 5—Pipe size selection curves. Oil pipe velocities should not exceed recommended maximum values shown and selection of pipe size should be based on that fact.

Bronze Coating Doubles Life of Steel Gears

IN A REPORT distributed by the Office of Technical Services, a casting process for the coating of steel gears with bronze is described as one of the most interesting and important developments in the German nonferrous foundry industry.

A shortage of tin led to this development. Although production was more expensive, the Germans claimed that bronze-lined gears had greater strength, longer life, and were generally superior to solid cast gears, especially for military equipment where great shock was exerted.

Investigators for the British Intelligence Objectives Subcommittee visited Germany in 1945 to examine copper-base, nonferrous sand foundries. It was discovered that sand foundries had been somewhat relegated to the background in Germany because of the shortage of tin and nickel. Using both static and centrifugal methods, the Germans had concentrated on lead-bronze linings for the manufacture of bearings for the military forces.

For example, at the firm of Braunschweiger Huttenwerke G.m.b.H. at Braunschweig-Melverode, a process for producing bronze-coated steel gears for rear axles was started in 1937. Solid bronze gears were said to have a life of approximately 50,000 kilometers. This figure was raised to 100,000 kilometers by the adoption of bronze-coated steel gears.

Gasheated furnaces were used for melting. The gear was placed in a grey cast iron mold lined with fireclay and heavy iron ring placed on top. The special-type bronze was cast into the annulus between the gear and the container. After cooling, the gear with attached bronze coating was removed and packed in a graphite sand mixture. This was followed by diffusion heat-treatment and final machining.

In general the British investigators thought the Germans to be ahead of United Kingdom manufacturers in the perfection of centrifugal casting techniques, especially in the production of long, small-diameter parts on horizontal machines, and long heavy-section bushings on vertical machines. Germans seem, as far as possible, to have abandoned ordinary copper-base sand casting during the war, except for such parts as could not be produced in lead-bronze or by centrifugal methods.

Report PB-34011, entitled "German Non-Ferrous Foundry Industry" sells for $3.50. Orders should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C. An additional OTS report on the same subject (PB 17565, "Bronze Coatings on Steel Gears in Germany," by Sam Tour, 50 cents) can be obtained from the Library of Congress, Washington 25, D. C.

Permanent Magnet Stability—II

Effects of mechanical shock, impact, vibration, and reluctance changes in the magnetic circuit of the flux output of permanent magnets. Thermal and a-c demagnetization stabilization treatments shielding methods, and nature of air gap flux density changes caused by external fields acting on permanent magnets are discussed.

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EFFECTS OF STRUCTURAL CHANGE and temperature change on the constancy of the flux output of permanent magnets, and the significance of metallurgical stability, magnetic stability and Curie Temperature as characteristics of permanent magnet materials were discussed in Part I of this article, see PRODUCT ENGINEERING, November, 1948, p. 131.

It has long been known that a magnetized bar of steel becomes demagnetized when subjected to vibration or impact. Permanent magnets, in much the same manner, become demagnetized under the influence of mechanical shock. After a magnet is magnetized, and the magnetizing field removed, its domains retain a certain amount of alignment, as indicated by its value or remanent induction, in the direction of the magnetizing field. Mechanical shock tends to reorient some of these domains in a random manner, and so becomes a demagnetizing influence.

The data given in Table IV and Fig. 7 seem to indicate that the degree of demagnetization depends largely upon the coercive force, or the tenacity with which the domains are held in the alignment given them by magnetization. This deduction is by no means conclusive, but the earlier quench-hardened alloys, with a relatively low coercive force, seem to be much more susceptible to demagnetization by mechanical shock than the present day diffusion hardening alloys as exemplified by the Alnicos.

In Fig. 7 are shown the relative resistance to demagnetization resulting from impact for specimens of Alnico, 36 percent cobalt, and tungsten magnet steels. These data were obtained by dropping magnetized bars a distance of one meter onto a wooden platform; the bars struck the platform on end. The bars were 10 in. long and $\frac{1}{2}$ in. square in cross-section. The curves of Fig. 7 indicate that the decrease in air gap flux is gradual; the changes are exponential in character and approach limiting values for the cobalt and tungsten steels. The total amount of change depends largely upon the magnitude of the repeated mechanical shock.

Table IV—Results of Impact on Alnicos

No. of Impacts	Percent Remanence Retained by				
	Alnico 1	Alnico 2	Alnico 3	Alnico 4	Alnico 5
20	100	100	100	99.7	*100
50	100	100	100	99.7	99.9
100	99.2	100	100	99.7	99.8
200	99.2	100	100	99.7	*99.8
300	99.2	*100	99.8	99.7	99.6
500	*99.2	100	99.6	99.7	99.5
750	99.2	*99.2	99.6	99.7	*99.5
1000	*99.0	99.2	99.6	*99.7	*99.5

* Indicates region where bars cracked or broke.

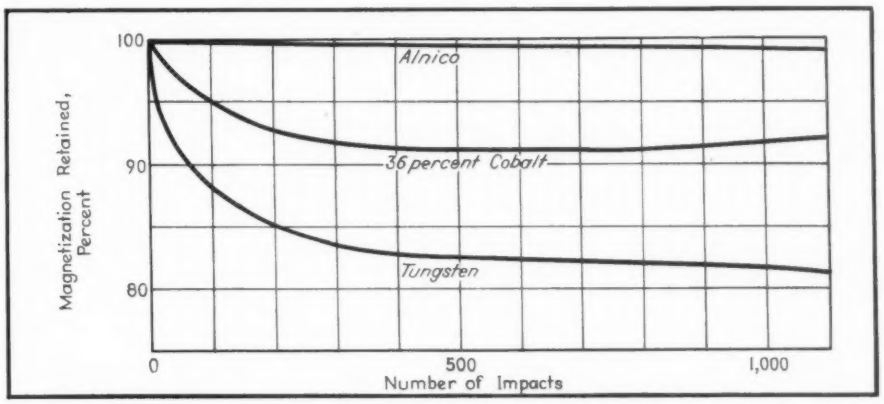

Fig. 7—Comparison of magnetization retained by three magnet alloys after repetitive impact. These data were obtained by dropping magnetized bars onto a wooden platform.

In Table IV are given results of the same impact test for various grades of Alnico.

As indicated in Table IV considerable breakage and cracking occurred in the impact test. With the Alnico type alloy it appears that physical properties will limit its use under conditions of impact, rather than the amount of demagnetization it suffers.

In one vibration test, conducted to indicate the magnitude of the remanence loss, magnet specimens were vibrated with a total displacement of 0.050 in. at frequencies from 10 to 50 cps for a period of forty minutes. The following remanence losses were noted:

Material	Remanence Loss, Percent
36% Cobalt	3.21
3.5% Chrome	0.0
Alnico 5	0.32
Alnico 2	0.33

In another type vibration test with one end of the magnet securely clamped, and a displacement of the free end of 0.25 mm at frequencies up to 120 cps for 1.5 hr, the following remanence losses were detected:

Material	Remanence Loss, Percent
36% Cobalt	0.77
3.5% Chrome	1.48
Alnico 2	0.81

These tests are by no means con-

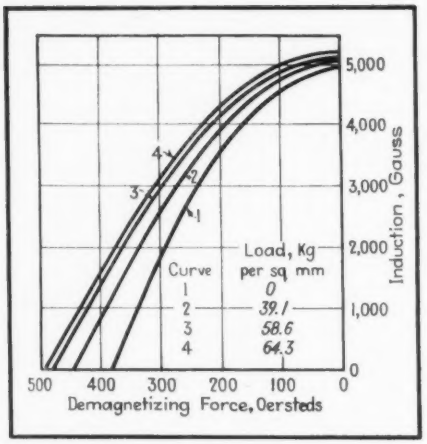

Fig. 8—Increase in the coercive force of a Cunife magnet alloy as the external tension on the specimen is increased.

clusive, but most materials do not exhibit large losses when exposed to such vibrations.

The problem of stabilization against the demagnetizing influence of mechanical shock has had little attention, because it is seldom encountered when using high coercive force precipitation hardened alloys. The advantage of these alloys is apparent. They should be utilized if possible where conditions of severe mechanical shock exist.

There are two types of stabilization that may be employed where necessary. One includes a thermal treatment or a-c demagnetization that reduces the amount of air gap flux change. The particular treatment must be arrived at by trial and error with the application in question. In the second method the apparatus, before it is calibrated and put into service, is operated under service conditions of mechanical shock until the air gap flux is stabilized. The conditions of mechanical shock vary so widely that each application must be treated as a special problem.

In the discussion of structural stability in Part I of this article, it was mentioned that mechanical work and plastic deformation generally alter the existing internal crystal orientation of the workable magnet alloys. Closely allied with this type of change, are the alterations in the magnetic properties of these materials under external tension and pressure.

Numerous investigations have been conducted on the effects of external tension and pressure upon the magnetically soft materials. H. Neumann, A. Buchner and H. Reinboth (See *Zeitschrift fur Metall Kunde*, Vol. 29, June 1937, pp 173-185) were the first to conduct such tests on permanent magnet materials. Under the conditions of their tests, these authors reported a marked increase in the coercive force of a Cunife magnet alloy as the tension was increased on the specimen. Fig. 8 taken from the work of these authors, demonstrates the shifting of the demagnetization curve under increasing tension, with the curves taken with the axis of magnetization in the direction of the applied load.

The predominate increase in coercive force is evident from this series of curves. After the load was removed, the initial magnetic properties reappeared even though the applied load had caused considerable elongation of the ribbon specimens.

External Magnetic Fields

Permanent magnets often operate in the vicinity of external magnetic fields, such as those set up around high current carrying conductors, arcs or coils. As is to be expected, these fields profoundly affect the air gap flux supplied by the permanent magnet unless proper precautions are taken to minimize their effects.

When the effective strength of an external field acting on a permanent magnet is known, the effect on the magnet flux output may be determined from the demagnetization curve. The effect of the field either while acting on the magnet or after the field has been removed may be determined, equally as well.

The term effective field strength is used advisedly, for it must be remembered that inserting any magnetic material with a large permeability into a uniform magnetic field tends to change or distort the external field pattern. The field set up by the magnet interacts with any externally applied field. The resultant external field strength acting on the magnet, therefore, may be quite different from the original external field strength. This phenomenon is sometimes referred to as the end pole effect. The fields set up by alternating currents can be treated as d-c fields, applied with the polarity reversed on successive applications, if the frequency of the alternating field is low enough to avoid serious eddy current effects.

The nature of the flux density changes caused by external fields can be conveniently studied with the aid of the demagnetization curve for the magnet material.

In Fig. 9 is shown a typical demagnetization curve of a permanent magnet material. Assume that a magnetic circuit containing a saturated permanent magnet, has an air gap corresponding to the permanence line *XO*. If the magnet is initially saturated, the intersection at point *a* of the air gap or permanence line with the demagnetization curve represents the operating point of the magnet and the flux density in the magnet. Now apply a d-c demagnetizing field of field strength *H*, the operating point then moves down the demagnetization curve to some point *b* dependent upon the strength of the applied field. From Fig. 9 it is seen that while field *H* is acting, the flux density in the magnet decreases by an amount ΔB as shown.

If this external demagnetizing field is removed, the operating point of the magnet will not return to its original position along the demagnetization curve, but will recoil along a minor hysteresis loop until it again intersects the original permanence line. For example as shown in Fig. 10, when the external field ΔH is removed the operating point moves from point *b*, its position while the external field is acting, along the minor hysteresis loop to

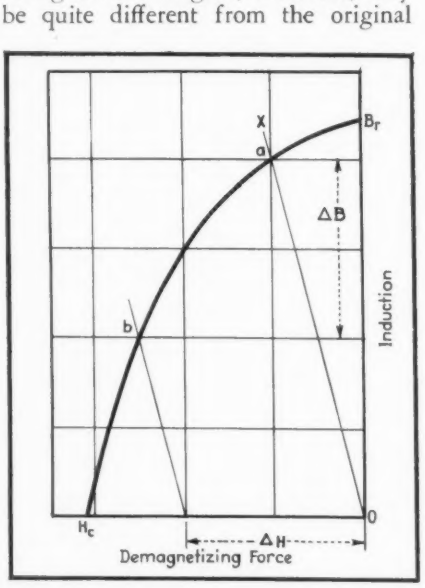

Fig. 9—Demagnetization curve of a permanent magnet and change of operating point caused by a d-c demagnetizing field.

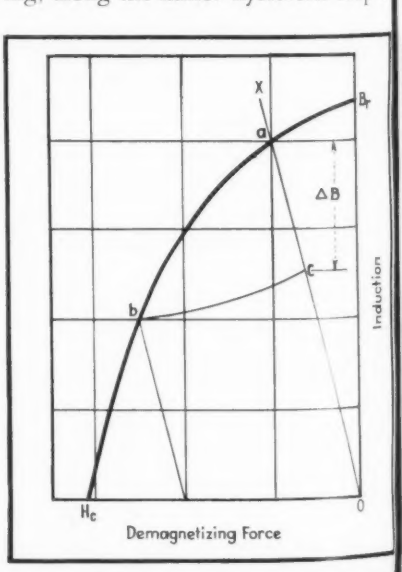

Fig. 10—Movement of operating point along a minor hysteresis loop when external field is removed from magnet.

point c, the intersection of this loop with the circuit permanence line XO. As the external field is removed the flux density of the magnet increases by an amount determined by the slope of the minor hysteresis loop. Yet when the field is completely removed, an overall decrease ΔB occurs in the flux density of the magnet from its original saturated value. The flux density loss ΔB can be recovered only by again saturating the magnet by remagnetization.

Further application of an external field having a strength no greater than that of the original field ΔH causes little further decrease in the flux density of the magnet. Repeated exposures to external fields result in further small decreases in flux density, because the first few minor loops do not close upon themselves. These minor loops tend to approach asymptotically a stable condition. After five or six cycles the minor loop will be retraceable and no further flux change will be detected.

Upon application of an a-c field, the operating point moves down the demagnetization curve and then retraces a minor hysteresis loop many times. When the field is removed the point recoils along the minor hysteresis loop to the permanence line much the same as shown in Fig. 10. If the a-c field is applied for any length of time the magnet takes on a cyclically magnetized condition and the further small decreases encountered on the first few d-c field applications will be negligible. For practical purposes, the common 60 cycle a-c field can be treated the same as repeatedly applied d-c fields of the same field strength.

The amount of flux change in a saturated magnet when an external field is applied, either while the field is acting or after it has been removed, depends to some extent upon the total reluctance of the magnetic circuit. In some materials an external field can have a widely varying effect, depending upon the location of the intersection of the circuit permanence line with the demagnetization curve, especially in anisotropic materials operating near or below the knee of their demagnetization curve.

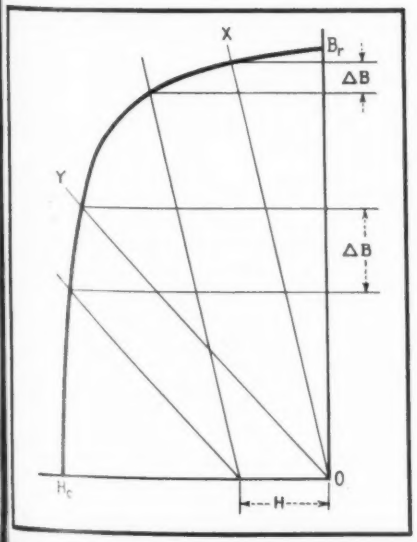

Fig. 11—Effect of an external field varies with the intersection of the permanence line and the demagnetization curve.

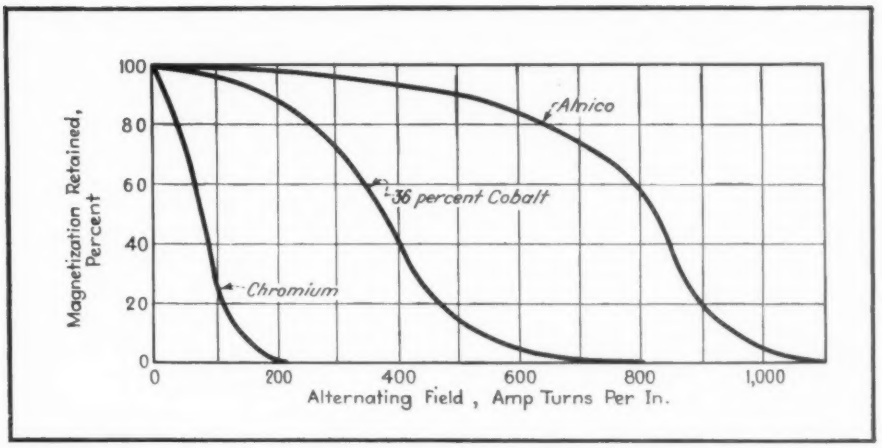

Fig. 12—Relative resistance of three permanent magnet materials to demagnetization by stray fields. Field was computed from current flowing in the solenoid.

This same effect is noticed for reluctance changes as is shown in Fig. 11, where it is seen that a small external field H causes little flux change in a magnet operating on permanence line XO. The same field applied to the magnet operating on the permanence line YO causes a considerably greater decrease in the flux density of the magnet. This decrease is particularly objectionable in magnet applications where large reluctance changes or large external fields are encountered.

A brief discussion here will answer the question: What is the limiting field strength that may be applied before a permanent magnet will supply no useful flux? A material's resistance to demagnetization under various conditions of an external field is largely a function of the coercive force H_c, and the relaxation coercive force H_{cr}. While an external field is acting on a permanent magnet, its coercive force H_c is the externally applied field strength that will reduce the resultant magnet flux density to zero. In other words, while a field equivalent to H_c is acting on a permanent magnet no flux will be supplied to an air gap.

If an external field greater than H_c is acting, the polarity of the magnetic field supplied by the magnet will be reversed. When such an external field is removed the magnet will assume its original polarity if the applied field did not exceed the relaxation coercive force H_{cr}. In many magnet materials the values of H_c and H_{cr} are nearly equal, but for materials such as the Heussler alloys the difference is considerable.

On the other hand, if an external field strength equivalent to the relaxation coercive force H_{cr} is applied and then removed, the magnet will be completely demagnetized and will supply no flux. A field strength larger than H_{cr} will leave the polarity of the magnet permanently reversed when such a field is removed. The ultimate resistance to demagnetization is a function of the relaxation coercive force H_{cr}. Fig. 12 shows the relative resistance to demagnetization of long bar specimens of three permanent magnet materials. The specimens were held in a 60 cycle a-c field for one minute. The field was computed from the current flowing in the solenoid and thus does not represent the actual field acting on the magnet.

Available data are scarce on the performance of magnet materials under the influence of high frequency external fields. I. F. Kinnard and J. H. Goss (See *AIEE Transactions,* 1941, Vol. 60, pp 431-439) and G. J. Wey (See *AIEE Transactions,* 1941, Vol. 60) have conducted experiments, with watt hour meter magnets, on the effects of rapid and repeated surge conditions similar to the fields encountered from lightning discharge currents.

The experiments show that the metallic permanent magnet materials are to some extent self-shielding against the effects of surge conditions, and exhibit continuing demagnetization with each successive surge for fourteen or fifteen surges, after which no further demagnetization is noticed for surges of the same magnitude.

An explanation of this behavior is not difficult. The effect of the first surge is limited to the outer shell of

material. When the field caused by the first surge is removed, the magnetized interior of the magnet immediately remagnetizes the outer shell and the magnetization of the whole magnet is reduced. On successive surges the external field penetrates deeper and deeper into the magnet further reducing its magnetization, until the fields resulting from the eddy currents in the penetrated layer are large enough to prevent further penetration by the external field.

The tests on nonmetallic Vectolite by I. F. Kinnard and J. H. Goss (See *AIEE Transactions*, 1941, Vol. 60, pp 431-439) show that these effects are dependent upon the conductivity of the magnet material. The oxide magnet was demagnetized by the initial surge but showed little further demagnetization after repeated surges of the same magnitude. The amount of demagnetization suffered by the materials tested was shown to be an inverse function of the coercive force. With a wider range of alloys, demagnetization under surge conditions is probably more precisely a function of the intrinsic coercive force or relaxation coercive force.

For magnet materials having a low intrinsic coercive force, electromagnetic shielding limits the penetration by external fields and allows these materials to compare more favorably with those of higher coercivity. This additional shielding is obtained by depositing on the surface of the magnet a thin layer of a high conductivity material such as copper. The protection afforded by the copper coating against large demagnetizing fields is notable, but its effectiveness is diminished if the magnet is not completely or uniformly covered. Chrome steel magnets thus shielded have made possible a more stable and accurate watt hour meter.

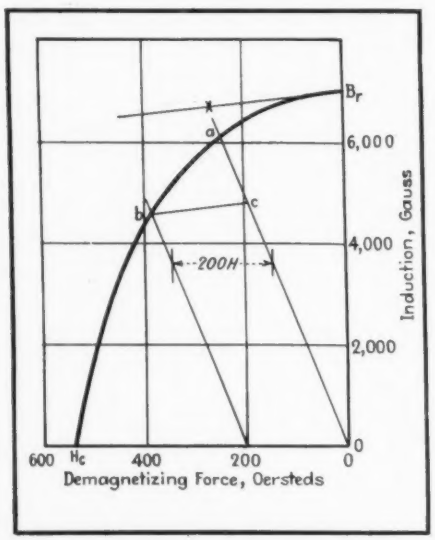

Fig. 13—Demagnetization curve of a fully saturated permanent magnet material.

Another method, referred to as magnetic shielding, is sometimes used to protect a magnet from the full influence of an external field. It is based upon the fact that a ferromagnetic material surrounding a magnet shunts off much of any existing external field.

If a soft steel ring is placed in a uniform magnetic field, there will be little effect resulting from the field inside of the steel ring. This screening or shielding effect is utilized in many sensitive instruments. To arrive at the set of conditions, however, that afford maximum protection by any shielding method is still a matter of experiment.

To reduce the total flux density decrease and to avoid any irreversible flux decreases caused by the action of external fields, the magnet can be given an a-c demagnetization, or knockdown as it is sometimes called. Since a-c fields leave a magnet in a cyclically magnetized condition, and so exhibit maximum stability, they are usually preferred for stabilization purposes rather than d-c fields. If the effective maximum strength of the external fields that will be encountered in service are known, a field as great or preferably slightly greater is used for the a-c knockdown.

The flux density remaining in a magnet after receiving a knockdown treatment can be closely calculated by following a simple procedure. Take as an example a fully saturated magnet that is to be stabilized against the effects of an external field of 200 oersteds. In Fig. 13 the demagnetization curve for the magnet material is shown with the magnet operating in the fully saturated condition on its permanence line *XO* at point *a*. First construct a tangent to the demagnetization curve at its intersection with the induction *B* axis. When specific information is not available on the slope of the minor hysteresis loops, they may be assumed to be approximately parallel to this tangent. For simplification, also assume that the minor loop is a straight line.

Next on the demagnetization curve select a point separated from the permanence line *XO* by a distance representing a field of 200 oersteds in a direction parallel to the *H* axis of the demagnetization curve. This procedure is shown in Fig. 13; through the point on the *H* axis representing 200 oersteds a line is drawn parallel to the permanence line *XO* that intersects the demagnetization curve at point *b*. From point *b*, the minor hysteresis loop is drawn parallel to the tangent constructed earlier and extended until it intersects the permanence line *XO* at point *c*. In this condition the magnet is stable, no further loss will be suffered upon exposure to field strengths less than 200 oersteds. If a field larger than 200 oersteds acts on the magnet, a further irreversible loss will be suffered.

Nearly the same stabilizing effect outlined in the preceding discussion may be obtained by increasing the reluctance of the circuit in such manner that the magnet will operate on the desired minor hysteresis loop. This result usually may be obtained by simply increasing the air gap in the magnetic circuit, returning it to its original dimensions, and repeating the operation several times.

Again it must be emphasized that while stabilizing techniques will greatly minimize flux change caused by an external field, they will not completely nullify flux changes that occur as the external field is acting. The magnitude of such changes depend upon the slope of the minor hysteresis loop of the magnet material.

Reluctance Changes in Magnetic Circuit

Many permanent magnets and permanent magnet assemblies exhibit flux changes that are not directly the result of the influences mentioned thus far, namely: Structural changes, temperature changes, mechanical shock and stray magnetic fields.

Flux changes can also result from reluctance changes in the magnetic circuit. Air gap variations resulting from the expansion or contraction of metals, mechanical shock or vibration, and unwitting variations by the human element are the chief causes of reluctance change. It is possible for reluctance changes to occur gradually and thus give the false impression that the resulting flux changes are a function of time.

The effects of reluctance change, such as variation of the circuit air gap, can be easily explained by following the performance of a magnet on its demagnetization curve such as shown in Fig. 14 (*A*). Point 1 represents the operating point of a saturated magnet, with an air gap in the circuit corresponding to the permanence line *XO*. As the air gap is increased the operating point of the magnet moves downward along its demagnetization curve to point 2, or until it meets the permanence line *YO* of the enlarged gap. The decrease in flux density occurring in the magnet is measured by the difference between the value of induction *B* for point 1 and that for point 2 on the curve.

Continuing, if the air gap is now returned to its original dimension the

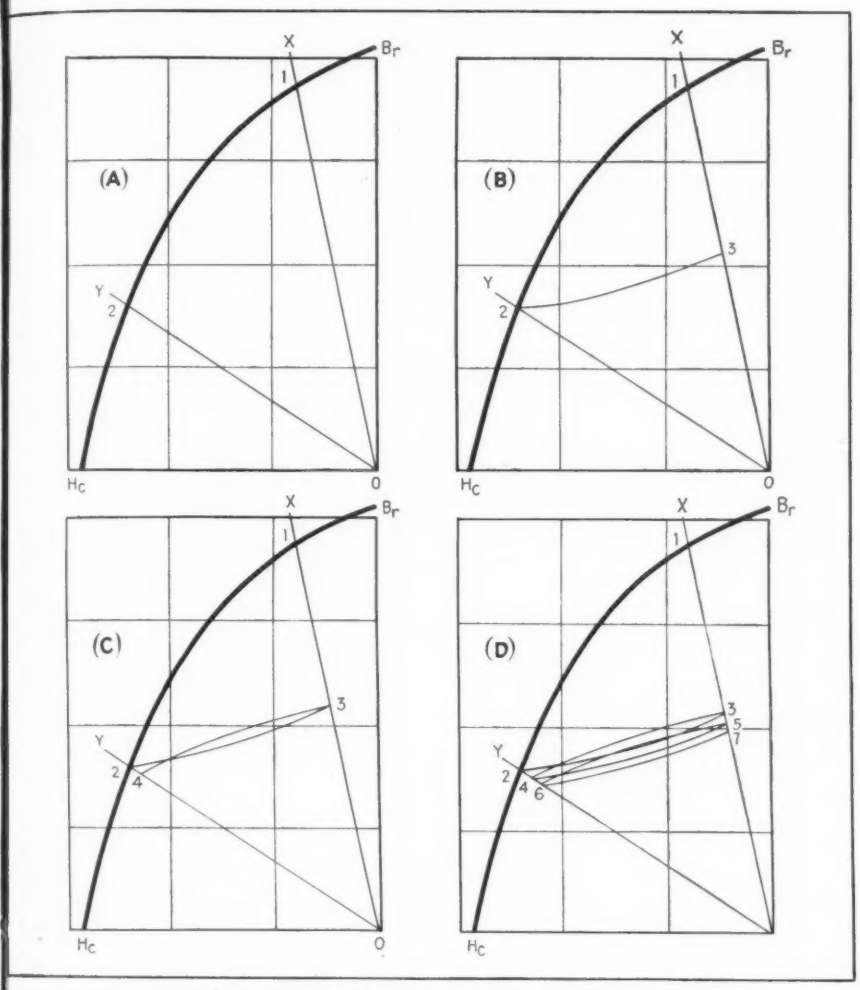

Fig. 14—Demagnetization curve and analysis of the effects of repeated cycles of reluctance change on flux density, such as results from variation of circuit airgap.

operating point of the magnet does not move back up the demagnetization curve, but recoils along a minor hysteresis loop until it intersects the original permanence line *XO* of the original air gap. This behavior is shown in Fig. 14 (*B*), where the operating point is initially at point 2, its position as caused by the influence of the enlarged gap. As the gap is returned to its original dimensions the operating point moves along the minor hysteresis loop to point 3, the intersection of this particular minor loop with the original permanence line *XO* of the magnet.

To illustrate a frequently encountered phenomenon further suppose that the magnet, after being exposed to one cycle of reluctance change and without remagnetization, is again subject to the same open circuit condition as represented by the permanence line *YO* of Figs. 14 (*A*), (*B*) and (*C*). In Fig. 14 (*C*) as the gap is increased for the second time, the operating point moves downward along a minor loop that does not form a closed loop at point 2. The loop now intersects the permanence line at point 4 some distance below point 2. As a result, a further decrease occurs in the flux density of the magnet under open circuit conditions that is recoverable only upon remagnetization.

This decrease can be measured by the difference of the *B* ordinates of points 2 and 4. If the circuit is returned again to the closed condition represented by *XO* the same phenomenon occurs. As shown in Fig. 14 (*D*) the points 3 and 5 are some distance apart. Repeated opening and closing of the circuit between the two permanence lines *XO* and *YO* as shown in Fig. 14 (*D*) results in a progressively decreasing flux density change in the magnet. After five or six such cycles no further change will be noticed and the minor loop will be retraceable.

This phenomenon of the initial irreversibility of the minor hysteresis loop occurs frequently in the use of permanent magnets. As a general rule the initial minor loop is not retraceable regardless of the nature of the particular influence that causes the magnet to operate on the minor loop. For practical purposes, to be retraceable the magnet must be in a cyclic magnetized condition, that is, it must be subjected to the magnetizing or demagnetizing influence several times before the flux will remain constant after an exposure to the influence.

The fact that the minor hysteresis loop is not initially retraceable may be demonstrated by two simple experiments. In the first, a steel keeper is placed across the poles of a fully magnetized C shaped magnet, and the force necessary to pull the keeper straight off the magnet poles is measured.

On the initial removal of the keeper a force is needed that is somewhat greater than that necessary on subsequent removals. The force necessary decreases successively after each removal, until after the fifth or sixth the force required becomes constant. The greatest percentage of decrease in the force necessary to remove the keeper occurs between that of the first and second removals. The force or pull is proportional to the square of the flux density at the magnet poles. Therefore, the difference in the force necessary on successive removals corresponds to the difference in the values of induction *B* between points 3, 5, and 7 of Fig. 14 (*D*) if the permanence line *XO* is close to the *B* axis.

A second test will demonstrate the performance of a magnet on its minor loop. This test requires a steel yoke as shown in Fig. 15 with a small air gap and an instrument to measure the flux in the gap. A fully magnetized magnet is inserted into the yoke as shown and the flux developed in the air gap measured. Then the magnet is removed completely from the yoke and then reinserted and the flux again measured in the air gap. This removal and insertion of the magnet is continued until the air gap flux remains the same for a number of insertions. Much the same as in the first demonstration, the flux in the gap decreases until after the fifth or sixth insertion

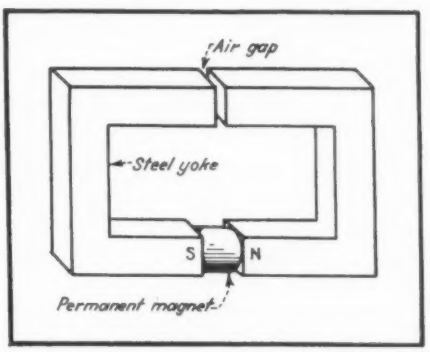

Fig. 15—Steel yoke used to demonstrate the performance of a magnet on its minor loop. Flux in the airgap is measured.

after which the flux remains constant. The greatest decrease also occurs between the first and second insertions.

In each of these two experiments, the phenomenon may be shown more directly by measuring the flux density of the magnet in the repeated open circuit conditions. Between each of the first few removals in the first experiment, and before each of the first few insertions in the second, this same decrease in flux density is found, and corresponds to the difference in the values of induction B for points 2, 4, and 6 of Fig. 14 (D).

The amount of flux change depends upon the amount of reluctance change and the characteristics of the material, its demagnetization curve and minor hysteresis loops. As has been shown, four kinds of flux change may be encountered with reluctance change in a magnetic circuit:

1. A single increase in the reluctance of a magnetic circuit containing a saturated permanent magnet will force the operating point of the magnet down its demagnetization curve and cause a corresponding amount of demagnetization.

2. A single decrease in reluctance of a magnetic circuit containing a saturated magnet will cause the magnet to recoil on a minor hysteresis loop and will result in an increase in useful flux.

3. A reluctance varying between specific limits, in a circuit containing a saturated magnet, will cause a decrease in useful air gap flux after each successive cycle of reluctance change until the magnet has reached a cyclically magnetized condition. The greatest loss will occur with the initial reluctance increase.

4. Finally, after the magnet is in a cyclically magnetized condition, the useful air gap flux will vary with the reluctance, by an amount that will depend upon the slope of the minor hysteresis loop. For any particular circuit reluctance, within the limits used to put the magnet in the cyclically magnetized condition, the air gap flux will be constant. In most work it is assumed that the minor hysteresis loop is a straight line. If the reluctance variations are large, a small difference in air gap flux may be detected as the reluctance increases and as it decreases because the minor hysteresis loop is not a straight line.

With a clear understanding of the effects of reluctance changes as exemplified by air gap variations, the methods used to stabilize a permanent magnet against such changes are probably self-evident. Essentially the magnet is brought into a cyclically magnetized condition, before it is put into useful service, by either of two methods that are essentially the same. In the first, the saturated magnet is subjected a number of times to reluctance change as large or slightly larger than the maximum change the magnet is expected to encounter in its anticipated service until the irreversible changes have occurred.

As an alternate method, an a-c demagnetization may be applied to the saturated magnet that will avoid the irreversible changes, as described in the previous discussion, and leave the magnet in a cyclically magnetized condition. C magnets, which are used to supply a specific putt or a positive snap action and that are not exposed to other demagnetizing influences, may be subjected to closed circuit conditions a number of times by shorting their poles with a steel keeper until a constant pull is obtained. Or in a quicker and more preferred method, if other demagnetizing influences are to be encountered, the magnet is subjected to a controlled a-c magnetic field of sufficient strength to give the proper stability and constant pull. Magnets like that shown in Fig. 15, before they are put into service, may be inserted and withdrawn from the steel yoke a number of times until the air gap flux becomes constant or given the proper a-c demagnetization.

In many applications, where the magnet operates under essentially static conditions no stabilization is required, as any reluctance change will necessarily be small and inconsequential. Under dynamic operating conditions, stabilization removes only the flux changes that are not fully reversible with reluctance change and does not seriously affect the reversible flux changes with reluctance, which are inherent in a permanent magnet material and which depend upon the minor hysteresis loop.

After a magnet has been magnetized and stabilized, either alone or in a magnetic assembly, it must not be touched along its surface with a ferromagnetic material; if touched flux will be diverted from the useful air gap. Touching or approaching the magnet with a magnetic material sets up consequent poles on the magnet surface, destroys the stable flux pattern within the magnet, and demagnetizes the magnet thus converting some useful air gap into useless leakage flux. Remagnetization is necessary to remove these consequent magnetic poles.

Summary

External magnetic fields, reluctance change, temperature change, mechanical shock and structural change are the most common causes of flux change in permanent magnets. All permanent magnets in useful service are affected in some degree by these disturbing influences, if their magnitudes are known the performance of the magnet can be closely calculated.

Exhaustive performance tests indicate that modern precipitation hardened magnet materials are structurally stable over a wide temperature range. With proper tempering treatments even the quench hardened alloys may be rendered stable in a limited temperature range.

No flux change is caused directly by the passage of time. Any of the influences discussed may act gradually or periodically and thus cause a corresponding gradual flux change in an unstabilized magnet.

In applications where it is desired to maintain an air gap flux as constant as possible, a magnetized magnet may be stabilized against the effects of external influences by subjecting it a number of times to conditions slightly greater than those expected to be encountered in service. Such treatment leaves the magnet in a condition of maximum stability, and removes that part of any flux change that is not reversible with the external influence. It is good practice to utilize some stabilization, even when the magnitudes of expected external influences are not precisely known.

Shielding can also be utilized to isolate a magnet from disturbing influences. Shielding permits magnet materials having a low intrinsic coercive force to compare more favorably with those of higher coercivity.

Assuming the material to be structurally stable, three fundamental qualities determine in a large measure the magnetic stability of a permanent magnet. These qualities are:

INCREMENTAL PERMEABILITY, which is a measure of the slope of the minor hysteresis loop and therefore a measure of magnet stability under a varying external influence.

COERCIVE FORCE, H_c. The limit of the external magnetic field strength that may act on a permanent magnet and yet obtain useful flux from the magnet while the field is acting.

RELAXATION COERCIVE FORCE, H_{cr}. The limit of the strength of an external field that may act on a magnet before it is completely demagnetized when such a field is removed. In practice, the coercive force H_c and the relaxation coercive force H_{cr}, are used interchangeably without serious error, since they are nearly equal for many magnet materials.

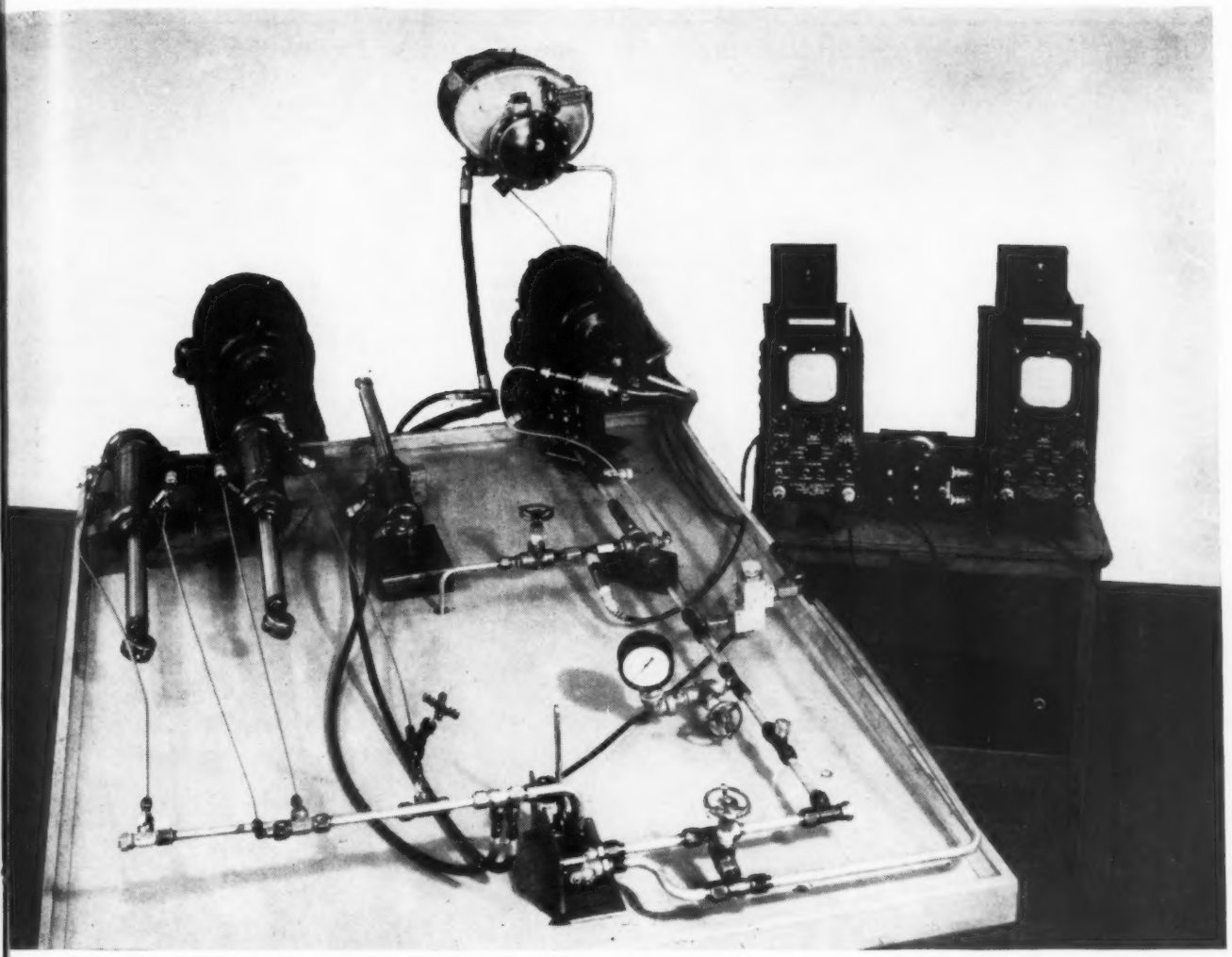

Fig. 1—Test set-up using several pressure pick-ups and two recording oscilloscopes to indicate instantaneous transient pressures.

Hydraulic System Testing

Newly developed test equipment for system analysis. How hydraulic systems can be studied by recording instantaneous transient pressures occurring within any of the components.

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HYDRAULIC SYSTEMS now can be performance tested and analyzed more completely and accurately than it was possible to do heretofore. The tool that has made this possible is the test equipment and technique developed by the Navy Bureau of Aeronautics and the Aeroquip Corporation. As a result, instantaneous pressures in all parts of a hydraulic system can be measured and recorded. The individual performance of valves, regulators and other hydraulic components can be studied, and the effect of external applied loads on the system measured accurately. Guesses as to performance and system variables are not necessary.

Test Equipment

The equipment used is similar to that for measuring static or dynamic stresses in structures. Pressure pick-up units installed in the hydraulic system at check points furnish the signal produced by variations in system pressure. This signal is amplified and fed into the tube of a cathode ray oscilloscope. Pressure variations in the system are thus plotted on the screen of the tube. Plots can be photographed if a permanent record is needed for subsequent detailed analysis.

A test set-up for an aircraft hydraulic system is shown in Fig. 1. Pressure pick-ups are shown at a number of points. These require only standard adapters and reducers. Although the pick-ups are not connected directly into the lines, tests have shown that this easier and more practical method of installation gives the same accuracy of resultant pressure readings.

The pick-ups are thin wall tubes with closed ends. Variations in system hydraulic pressure cause the tube to flex and change the length of a resistance wire wrapped around it. Wire resistance changes linearly with change in wire length, hence the current flowing through the wire varies directly with hydraulic pressure.

The pick-up wire is one leg of a balanced Wheatstone bridge. Any change in wire resistance produces a signal for

* *The opinions expressed in this article are those of the author and are not to be construed as official opinions of the United States Navy Department.*

Table 1—Effect of System Changes on Performance as Indicated by Pressure Plots

No.	System Condition	Effect on Pressures and Operation
1.	Trapped air	Moderate quantities (10 cu in.) at any place in the system had very little effect on pressures. Between regulator and accumulator, air column served to damp-out small impulse wave.
2.	Air leakage into pump intake	Amplifies pump ripple immensely, producing high frequency pressure waves of about 500 cps with peaks to 25 percent over operating pressures.
3.	Various accumulator air charges	Atmospheric—Produces rapid regulator action as system pressure quickly drops when fluid is flowing. Peak pressures are about 10 percent over operating pressures. 1,500 psi—Normal pressure valves, slowest regulator action. 2,500 psi—Normal pressure valves, fast regulator action since only small amount of fluid enters regulator as it is being charged.
4.	No accumulator in system	Extremely rapid regulator action with no stroke, as the fluid leads out of closed center. Pressures 30 percent over operating pressures as response of regulator is too slow to meet requirements.
5.	Various lengths of lines in power and sub-system	Increased length of line between regulator and accumulator increased kinetic energy of fluid at regulator cut-in, producing small impulse wave increase to 10 percent over operating pressures. Increased length of line in pump discharge had no effect. Increased length of line in operating system had no effect with normal slow selector valve action. With very rapid selector valve action, impulse pressure peaks up to 50 percent over operating pressures were produced at the ends of operating lines.
6.	Manual control selector valve operating speeds	Speed of manual control valve operation determines magnitude of impulse pressure wave. Rapid action produced waves with peak pressures to 50 percent over operating pressure. Slow action of the selector valve resulted in no impulse waves being formed.
7.	Flexible tubing	Use of flexible tubing damps-out pressure waves considerably by greater absorption of energy in expansion.
8.	Negative reservoir head pressures.	When the static head of reservoir fluid was changed from 30 in. above the pump to 15 in. below, there was no change in pressure values.
9.	Pressurized reservoir	Five psi pressurization did not affect the pressure curves produced.
10.	Assimilated flight maneuvers	When the regulator is directing the pump discharge into the return lines, and the reservoir then inverted momentarily to fill the intake lines with air, the pumps immediately discharge the air into the return lines and resume normal functioning. If the regulator is cut-in during inversion, the system pressure must be dropped to zero before the pumps are capable of removing air from the intake lines.
11.	Solenoid control valve operating speeds	Speed of solenoid control valve operation determines magnitude of impulse pressure wave. Solenoid operating times less than 0.02 sec produced waves with peak pressures to 60 percent over the normal operating pressure. Generally, solenoid operating times greater than 0.25 sec will not produce a peak pressure above the normal operating pressure, providing all other conditions are favorable.

the oscilloscope. Shown in Fig. 2, is a sketch of the pick-up unit. A second wire wound around the solid closed end of the unit is a second leg of the Wheatstone bridge. This wire compensates for temperature changes only and is not affected by pressure.

The rest of the electrical system including the regulated direct current supply for the bridge, the high gain, direct current amplifier and the cathode-ray tube with its controls, will not be described in detail. It is sufficient to say that the system shown was designed for both test and field use. As such it is a useful tool for hydraulic system performance testing.

This particular test equipment was designed to do the following:

1. Measure system pressures in the laboratory and in the field.
2. Operate on Naval aircraft at altitudes from sea level to 30,000 feet.
3. Measure pressures between vacuum and 15,000 psi.
4. Measure static and transient pressure variations occurring as rapidly as 20,000 times per sec (variations for most systems do not exceed 3,000 times per sec).
5. Present the pressure data as a plot on the cathode-ray screen with pressure as the ordinate and time as the abscissa. With this equipment, it is possible to present data at low or high tracing speeds, so that cyclic pressure phenomena of low frequencies, pressure phenomena at high frequencies and other transients can be studied in detail.

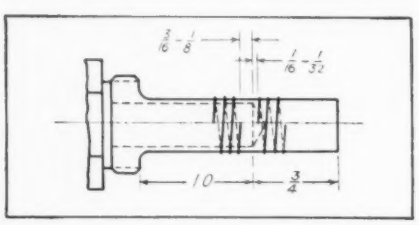


Fig. 2—Sketch of pick-up that converts hydraulic pressures to equivalent electrical resistances.

Hydraulic System Pressures

This useful test tool can play a large part in improving the performance, life and reliability of hydraulic systems and individual hydraulic components. By being able to observe in detail and to measure accurately system variations, the designer has a means for establishing comprehensive and realistic design specifications. Instead of designing for normal system operating pressures, and then applying arbitrary factors of safety, he can work directly with test data.

In any hydraulic system, the pressures produced at any point in the system depend on the operating characteristics of the components making up the system. These characteristics are, in turn, influenced by external conditions such as applied loads, point of application of the loads and their pattern, the arrangement of the hydraulic components in the system and their relation to each other; also internal conditions, such as the fluid mass flowing, fluid velocities, fluid accelerations and the rate of component operation.

High frequency pressure waves and dynamic impulse shock waves are set up when components and/or installations are improperly designed, when valves chatter or when applied loads fluctuate. Transient pressures in a system can easily build up to one and a half times normal operating pressures. And under unusual conditions, dynamic pressures may be four or five times their normal value. These excessive pressures can be reduced by analyzing the pressure curves and changing either the characteristics of the system components or their arrangement.

System Analysis

Some data from a test program undertaken by the Navy Bureau of Aeronautics are given here to illustrate how this test technique can be used to im-

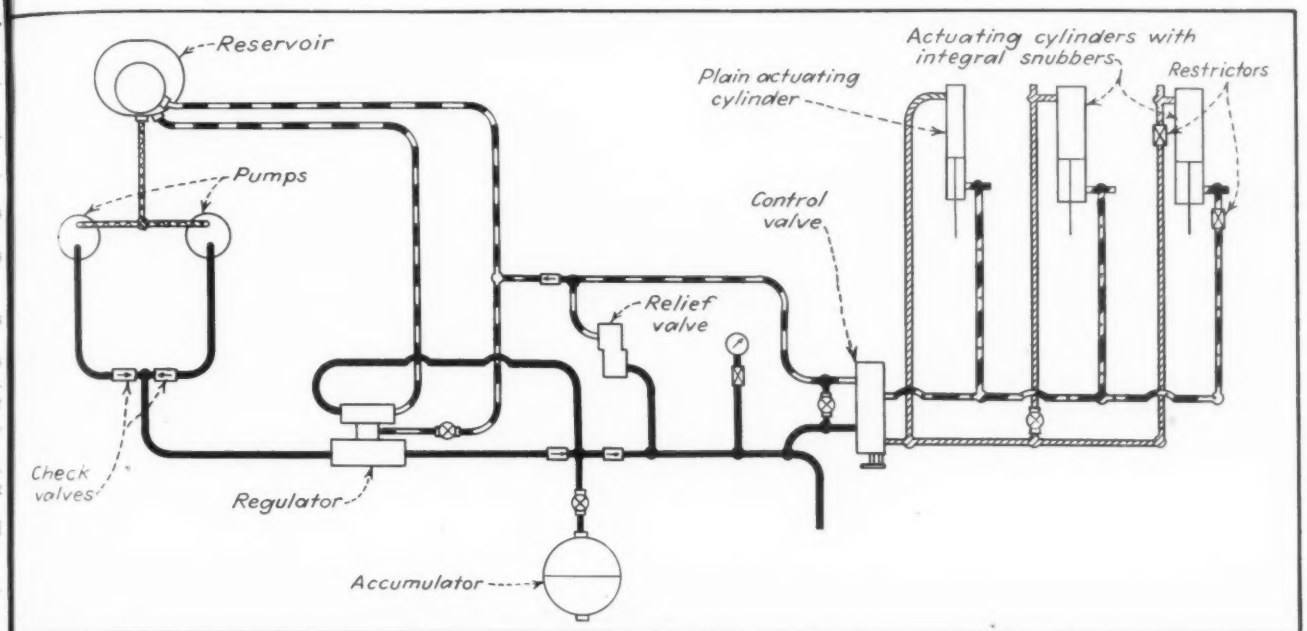


Fig. 3—Schematic arrangement of aircraft hydraulic system used for determining performance characteristics of components.

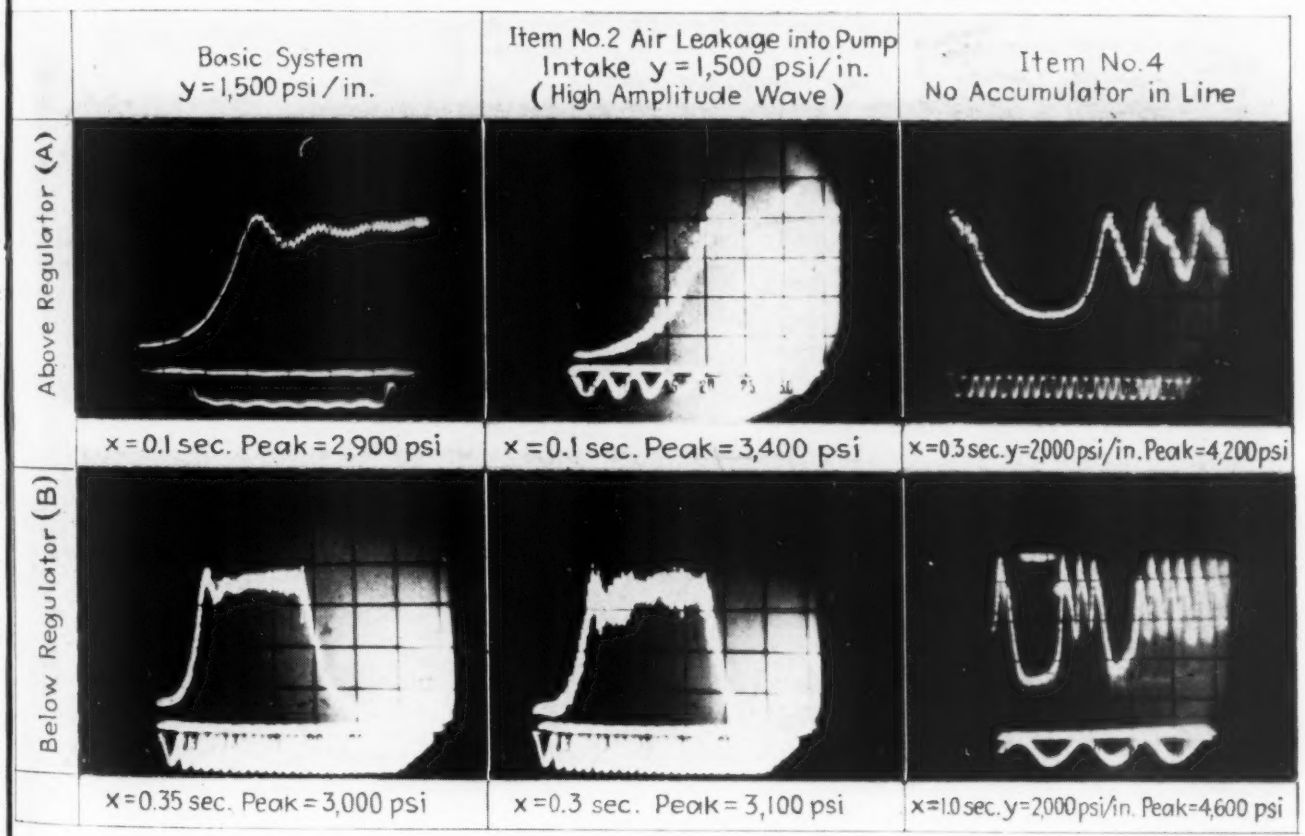

Basic System
y = 1,500 psi / in.
Item No.2 Air Leakage into Pump Intake y = 1,500 psi/ in. (High Amplitude Wave)
Item No.4 No Accumulator in Line
Above Regulator (A)
Below Regulator (B)
x = 0.1 sec. Peak = 2,900 psi
x = 0.1 sec. Peak = 3,400 psi
x = 0.3 sec. y = 2,000 psi/in. Peak = 4,200 psi
x = 0.35 sec. Peak = 3,000 psi
x = 0.3 sec. Peak = 3,100 psi
x = 1.0 sec. y = 2,000 psi/in. Peak = 4,600 psi

Fig. 4—Performance of basic system and two modified systems is compared. Oscilloscope plots show pressure variations with time.

prove a hydraulic system. In Fig. 3 is shown a complete system for actuating aircraft landing gear, dive brake and wing cylinders. A number of different hydraulic units are used, including pumps, accumulator, relief, check, regulator and selector valves, and actuating cylinders.

Tests were run to check following:

1. Air trapped in the system.
2. Air leakage into pump intake.
3. Accumulator air preload charges.
4. No accumulator in the system.
5. Various lengths of lines in the power and sub-system.
6. Manual control valve operating speeds.
7. Flexible tubing vs rigid tubing.
8. Negative reservoir pressures.
9. Positive reservoir pressures.
10. Reservoir at various altitudes to assimilate flight maneuvers.
11. Solenoid control valve operating speeds.

Test results are shown in Table I. These results were derived from oscilloscope plots taken from the system shown at various pick-off points. Fig. 4 shows typical plots covering the basic system as compared to the curves obtained with the basic system modified for conditions (2) and (4) specified above. By comparing the curves with

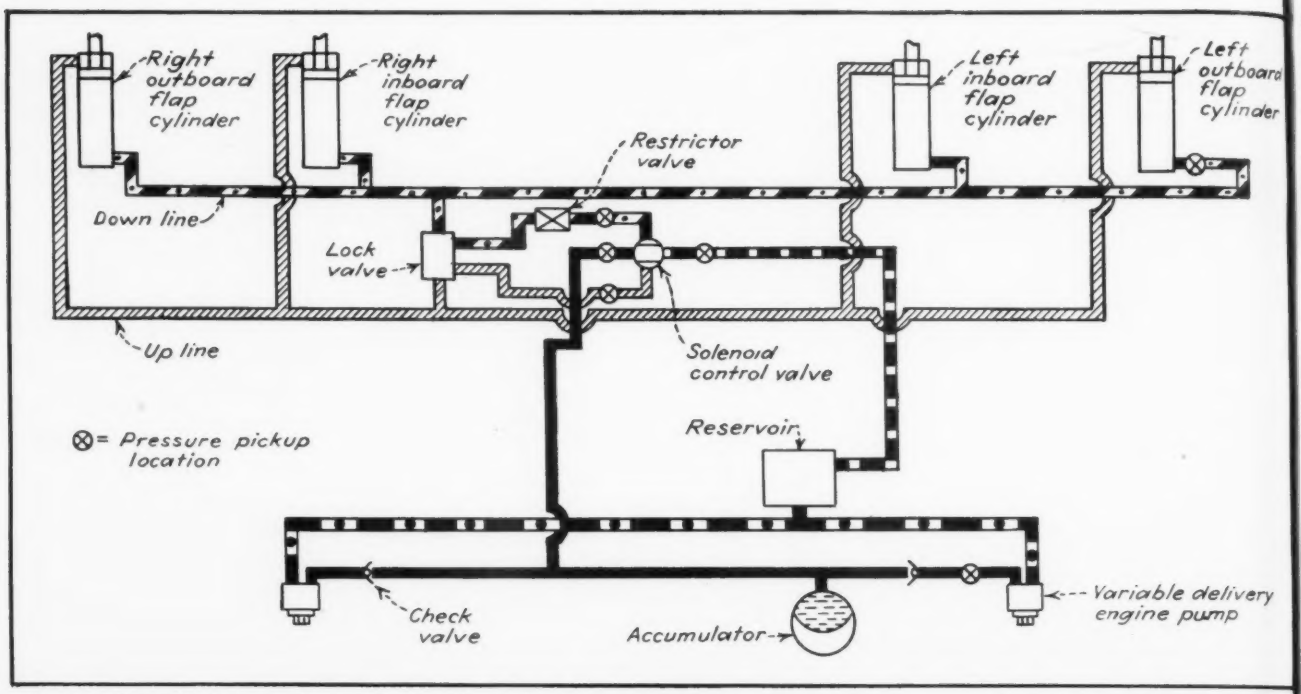


Fig. 5—Schematic diagram of aircraft wing flap hydraulic system. Pick-ups respond to pressures in lines to various components

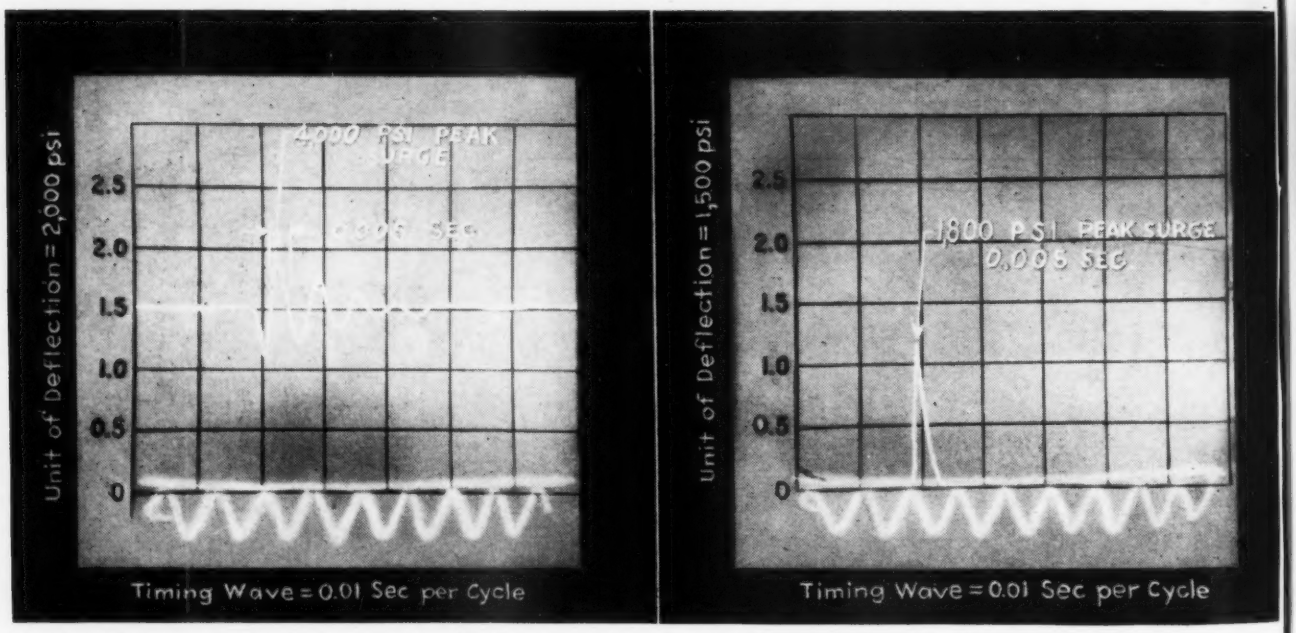


Fig. 6—Oscillograms of peak pressures in wing flap-hydraulic system. Timing waves provide data regarding duration of surges.

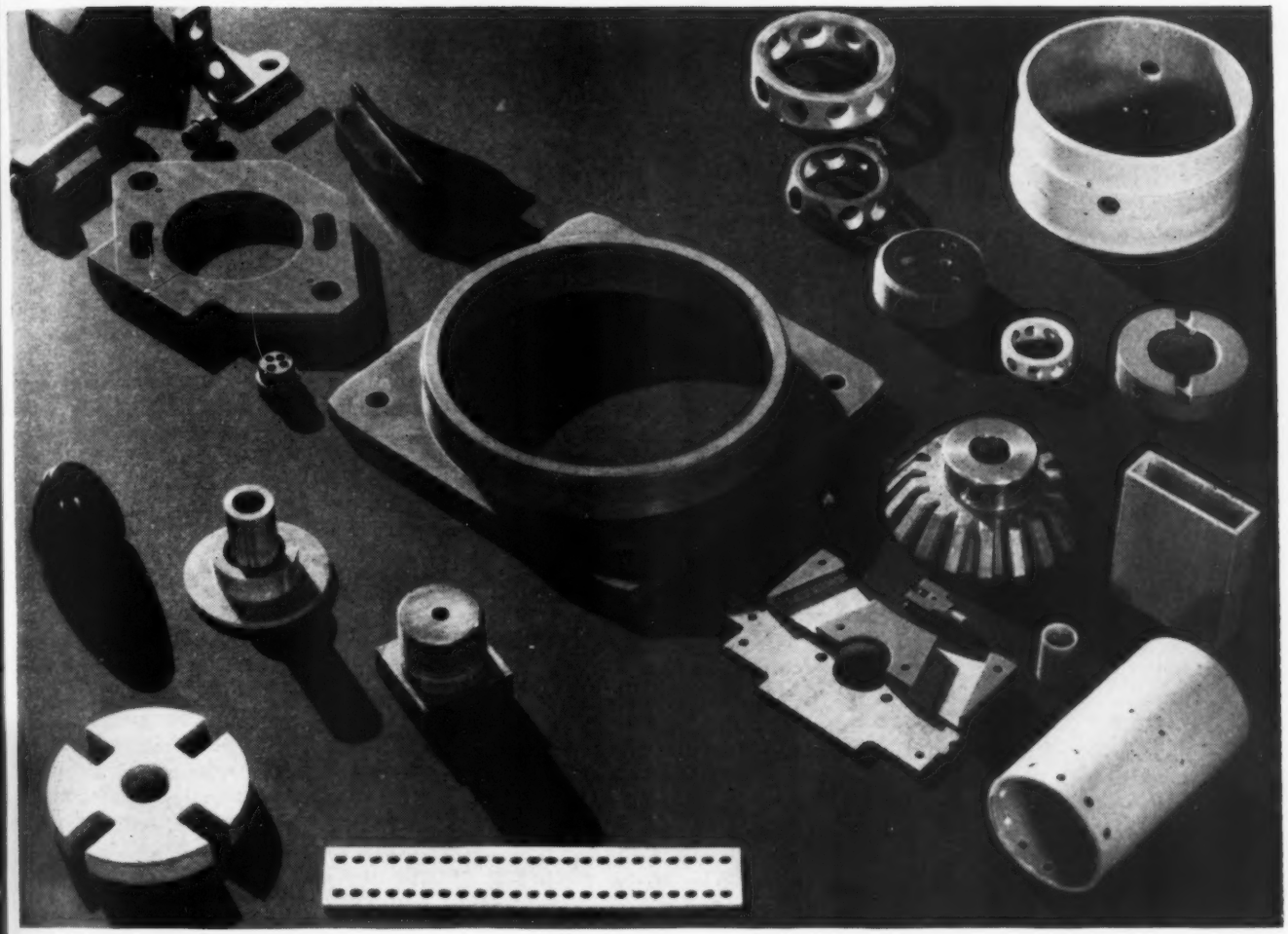
a standard data book covering all possible conditions, any system can be rapidly analyzed and redesigned or corrected to eliminate any damaging pressure surges that may be encountered.

An actual aircraft wing flap hydraulic system is illustrated schematically on Fig. 5. The curves shown in Fig. 6 indicate the transient peak pressures encountered. The normal pressure for conditions shown by the trace in the left oscillogram is 3,000 psi, that for the right illustration is zero.

In analyzing these curves it must first be noted that current requirements specify that peak pressures resulting from any phase or system operation must not exceed a value greater than 120 percent of the normal main system, sub-system or return system pressure.

Therefore, for the pair of curves in Fig. 6, obtained in analyzing the flap hydraulic sub-system of this airplane, it is found that the pressure line and return line to the flap control valve, in both cases, have peak pressures exceeding the maximum allowable requirements. Thus corrective action must be taken to reduce these surges. As a solenoid control valve is used in this circuit, it can be first assumed that Item 11 of Table I would apply as the interpretation for the high pressure wave. By increasing the solenoid operating time, the damaging pressure waves should be eliminated. This procedure is followed for all subsystems and the power system.

When sufficient information is available regarding transient pressures in hydraulic systems, designers will be able to work with safety factors that are appreciably less than those currently associated with hydraulic equipment. This decrease in the values of safety factors can result in a small saving of weight at each component in the system, and a considerable overall weight reduction. In aircraft, this factor is important.



INDUSTRIAL PARTS molded, machined and punched from thermosetting laminate materials include gears, couplings, ball bearing retainer rings, coil forms, fasteners and other units for high volume chemical, electrical and mechanical applications.

Thermosetting Plastic Laminates—I

A wide variety of engineering properties is achieved by combining various paper, cotton and glass fabrics with thermosetting synthetic resins. High strength-weight ratio, heat and corrosion resistance, and excellent electrical properties have made this class of materials a permanent addition to the collection of available structural materials. The first part of this series describes grades standardized by fabrication, composition and properties.

NORMAN A. SKOW
Director of Research, Synthane Corporation

THERMOSETTING LAMINATES, produced by applying heat and high pressure to layers of paper or fabric impregnated with thermosetting synthetic resins, are now considered standard engineering materials, and are used in every type of industrial product. Unlike the newer "low pressure" or "contact" laminates (see PRODUCT ENGINEERING, March 1947, page 160), these materials are laminated at temperatures from 270 to 340 F and pressures from 1,000 to 2,000 psi, depending on the type of resin and filler used.

These materials are exceptionally versatile because of their combination of properties. They are light in weight (about ½ the density of aluminum), have a high mechanical strength, good electrical properties, are resistant to moisture and chemicals, easily machined, and dimensionally stable. The laminates are manufactured in the form of sheets, tubes, rods, and molded shapes and in various grades, colors, finishes, and dimensions.

Fillers

The common filler materials used in high pressure thermosetting laminates are paper, cotton fabric, asbestos paper and fabric, staple fiber and continuous filament glass cloth, and nylon fabric. The papers used are either alpha or kraft type. The alpha type is more expensive since it is almost pure cellulose made from wood. Laminates made from Kraft are mechanically stronger than alpha base laminates but they are not as resistant to moisture and therefore are not as good electrically. Paper base laminates are specified where electrical properties rather than high mechanical strength are the chief requirements.

Cotton fabric fillers are specified in applications where mechanical strength is important. They have much higher

impact strength and bonding strength (cohesion between layers) than paper grades, but are not as good in electrical properties. Because of these mechanical properties, cotton fabric laminates have replaced metals, wood and ceramics in many applications.

Asbestos-base materials are used where heat resistance is the important property consideration. All high pressure thermosetting laminates are dimensionally stable when heat is applied but the asbestos grades are indicated for applications over 250 F. Used in either paper or fabric form, the asbestos-base laminates exhibit excellent dimensional stability when exposed to moisture. However, their electrical properties are not as good as paper and cotton fabric-base laminates.

Glass cloth-base laminates are superior to other grades in heat resistance and mechanical properties, particularly in impact strength. Electrical properties are better than the cotton and asbestos grades. Glass cloth is much more expensive than the other filler materials, but justifiable when a special combination of properties is needed.

Nylon fabric is a relatively new base material for high pressure thermosetting laminates. Its outstanding characteristic is a combination of superior moisture resistance and excellent impact strength. Its present use is in electrical parts where the moisture resistance of a paper-base laminate plus high impact strength is desired. Its cost is comparable to glass-base laminates.

Resins

The resins used to impregnate sheet fillers for thermosetting laminates are phenol formaldehyde and melamine formaldehyde combinations. Three varieties of phenolic resins are used: First, the straight or unmodified phenolic resin which is used for the hard variety of laminate, known as "hard varnish." Second, a phenolic resin to which a plasticizer is added. This resin, an ingredient of the punching (P) grades, is softer and permits the laminates to be sheared and punched. Since the cost of machining is obviated, economical fabrication of complicated shapes from flat or tubular stock is possible.

The third type of laminating varnish is a chemical variant of straight phenol formaldehyde—a modified phenolic. The unusual advantage of this varnish is that it can be formed in two stages. In the first stage the impregnated base is heated and formed to produce a flat sheet. In the second or final stage the sheet can be reheated and formed by post-forming methods. This is an economical process, since only simple forms are required for shaping, thus eliminating mold costs.

The straight or "general purpose" phenolic resin is used because of the rigidity it imparts to the laminated product. It is not generally punched or sheared except in thin sections. However, drilling and other machining operations are easily accomplished.

Melamine resins are used in decorative or surface applications, and in electrical applications where arc resistance is important. Melamine resins are white in color, light fast, and can take pigments of almost any shade. Phenolic resins have limited color possibilities—usually black and natural.

Melamine resins are useful in chemical applications, especially for resisting alkaline compounds. In high voltage arc applications, many resins fail because of "tracking", but the performance of melamine resins is outstanding. Its slightly higher cost is justified in such products as switches and electrical shields.

Melamine resin-bonded laminates are characterized by extreme hardness, abrasion resistance and light fastness; they are unaffected by inert organic solvents; their water absorption is low.

Processing

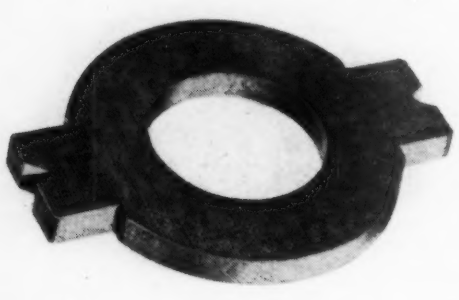
To manufacture the laminates, the resins are dissolved in alcohol or other suitable solvents to form varnish solutions for impregnation or coating of the fibrous fillers. After impregnation and drying the material is cut into sheets, which are stacked between metal pressing plates and pressed under high temperatures and pressures. During this operation the resin is transformed from a fusible, soluble stage into one that is practically infusible and insoluble. When the material has been heated for a sufficient time to bring this change of state to completion, the so-called "thermosetting" stage, the presses are cooled and the finished laminated sheets removed.

Tubes are formed by rolling the impregnated sheet materials on mandrels between heated pressure rolls and either oven baking or pressing in a heated mold to complete the cure or setting of the resin to its infusible form. Rods are usually made by molding laminations of impregnated sheet material in cylindrical molds under high temperature and pressure and grinding to size. Rods can also be machined from sheets.

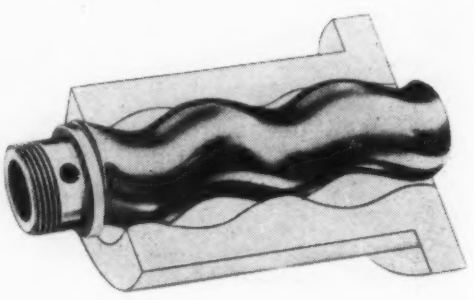
To make molded shapes, impregnated sheet materials are cut into various sizes and shapes to fit the contours of a mold, and molded under heat and pressure. For special applications, macerated sheet material is used alone or in combination with these molded-laminated materials.

Available Grades

While the properties of high pressure thermosetting laminates can be varied over a wide range by changing



WATER PUMP SEAL WASHER for automobiles is punched and surface lapped from grade L or AA sheet to dimensions of $\frac{1}{4}$ in. thick, $1\frac{5}{8}$ in. long, and $\frac{13}{32}$ in. ID. Replacing molded carbon, the washer resists constant wear, spring load of 20 lb, and immersion in engine water containing commercial anti-freeze.



STATOR of chemical pump resists attack of many corrosive solutions and the scrubbing action of pulp and solid particles. Molded-macerated of grade L material, the plastic laminate replaced bronze in this application. Although shown cut in half, the part is molded in one piece, including inner spiral.

the combination of resins, sheet fillers, modifiers and manufacturing processes, it has been found that a high percentage of applications can be satisfied with a reasonable number of standard grades. As shown in Table I, almost any combination of specific properties can be achieved by the correct selection of filler and resin. There are further refinements of each specific grade which can be especially manufactured for the designer, if he desires a special combination of properties.

The grade numbers given in the following listing were taken from publication No. 46-118, entitled "Standards for Laminated Thermosetting Products", of the National Electrical Manufacturers Association (NEMA). At present, NEMA is considered to be the most authoritative source for standards of high pressure thermosetting laminates. The relatively few new grades not yet classified by NEMA are so indicated.

GRADE X. A strong paper-base material laminated with straight phenolic resin, primarily intended for mechanical applications where electrical requirements are of secondary importance. Suitable for electrical applications under oil or when dry, but should be used with discretion where high humidity conditions are encountered. Not equal to fabric-base grades in impact strength. Medium bonding strength. Available in sheets and tubes, it can be punched cold up to $\frac{1}{32}$ in., warm to $\frac{1}{16}$ in., and hot to $\frac{3}{32}$ in. thick.

GRADE XX. A paper-base laminate, containing a larger percentage of straight phenolic resin than Grade X. It is suitable for usual electrical applications, except where high humidity conditions are present, and has good machinability. Available in sheets, rods and tubes. Medium bonding strength.

GRADE XXM. (Not yet classified by NEMA). Paper-base, same as grade XX, laminated with melamine resin. Same properties as Grade XX, except better arc, flame and alkali resistance. Available in sheets, rods and tubes; almost unlimited color range.

GRADE XXX. A paper-base laminate containing a larger percentage of straight phenolic resin than Grade XX. Excellent electrical properties—low power factor. Suitable for radio frequency and high humidity applications. Fair mechanical and low impact strength. Medium bonding strength. Exhibits minimum cold flow characteristics. Available in sheets, rods and tubes.

GRADE XP. A strong paper-base material, laminated with a plasticized phenolic resin. Primarily intended for punching—suitable for intricate mechanical and electrical parts. Medium bonding strength. More flexible and not quite as strong as Grade X. Moisture resistance and electrical properties intermediate between Grades X and XX. Available in sheet only, it can be punched cold to $\frac{1}{16}$ in., warm to $\frac{3}{32}$ in. and hot to $\frac{1}{8}$ in. thick.

GRADE XXP. A paper-base laminate, containing a greater percentage of plasticized phenolic resin than Grade XP. It is similar to Grade XX in electrical and moisture resisting properties, but more suitable for hot punching. Intermediate between Grade XP and XX in cold flow characteristics. Available in sheet only.

GRADE XXXP. A paper-base laminate containing a larger percentage of plasticized phenolic resin than Grade XXP. Similar to Grade XXX, but with better electrical properties—lower dielectric losses—greater cold flow; is more suitable for hot punching. Available in sheet only and can only be punched while hot.

GRADE C. A heavy weave fabric, weighing over 4 oz per sq yd, laminated with straight phenolic resin. Excellent mechanical properties—a strong, tough material, suitable for gears and other applications requiring high impact strength. Good bonding strength. Should not be used for electrical applications, except for low voltages. Although Grade C has better mechanical properties, Grade L should be used when the design calls for thin sections. Available in sheets, rods, tubes, and for molded-laminated and molded-macerated applications.

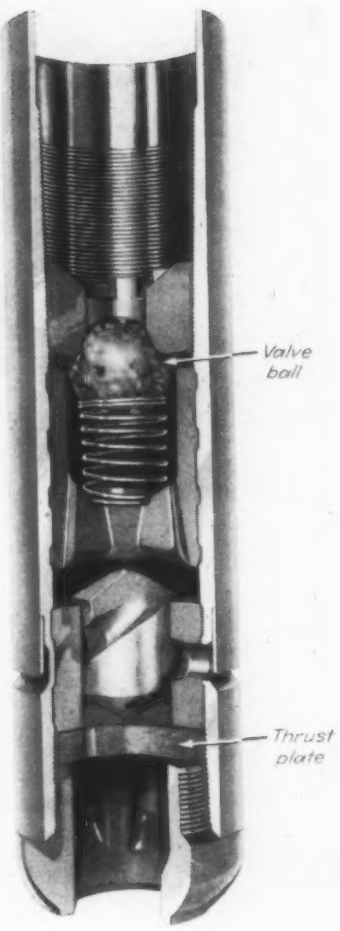
GRADE CM. (Not yet classified by NEMA). Cotton fabric base, same as Grade C, laminated with melamine resin. Properties are same as Grade C, except better for arc, flame and alkali resistance. Available in sheets, rods and tubes.

GRADE CE. Heavy weave fabric base, same as Grade C, laminated with a greater percentage of straight phenolic resin. Although its electrical properties are not as good as the paper-base grades, it is specified for electrical applications requiring greater toughness than Grade XX, and for mechanical applications requiring greater resistance to moisture than Grade C. It is, in fact, exceptionally good in moisture resistance. Available in sheets, rods and tubes.

GRADE L. A fine weave cotton fabric, weighing four oz or less per sq yd, laminated with straight phenolic resin. This grade is suitable for small gears and other fine machining applications particularly in thickness under $\frac{1}{2}$ in. Not quite as tough but better dielectric strength and resistance to moisture absorption than Grade C. Should not be used for electrical applications except for low voltage. Available in sheets, rods, tubes, and for molded-laminated applications.

GRADE LM. (Not yet classified by NEMA). Cotton fabric base, same as Grade L, laminated with melamine resin. Properties same as Grade L, except better for arc, flame, and alkali resistance. Available in sheets, rods and tubes.

GRADE LE. Cotton fabric base, same as Grade L, laminated with greater percentage of straight phenolic resin than Grade L. It is indicated for electrical applications requiring greater toughness than Grade XX. Not as



CEMENT FOR OIL WELLS, pumped through these "float shoes", gives hard use to the laminated plastic valve ball and thrust plate. Formerly made of brass or bronze, the ball is molded-macerated of Grade C material and then machined. The thrust plate, machined from Grade C sheet (replacing bronze), must take wear of rotating metal part above it.

strong mechanically as Grade L, but better machining properties and finer appearance than Grade CE—also available in thinner sizes. Exceptionally good in moisture resistance. Available in sheets, rods and tubes.

GRADE A. Asbestos paper laminated with straight phenolic resin. More resistant to flame and slightly more resistant to heat than other laminates. Temperature limitation is approximately 225 C for a short time—1 hr or less. Above 200 C, mechanical properties are approximately 20 percent lower than at room temperature. At room temperature mechanical strength is fair, impact strength good, resistance to splitting fair and dielectric properties fair. Excellent moisture resistance. Suitable for high temperature mechanical applications, where heat causes organic fillers to fail or lose considerable strength. Available in sheets, rods and tubes.

GRADE AM. (Not yet classified by NEMA). Asbestos paper laminated with melamine resin. Properties same as Grade A, except better arc, flame and alkali resistance. Available in sheets, rods and tubes.

GRADE AA. Asbestos fabric laminated with straight phenolic resin. Properties similar to Grade A, but stronger and tougher. Suitable for low voltage applications. Minimum dimensional changes when exposed to moisture—better than most other grades in moisture resistance. Available in sheets, rods and tubes.

GRADE AAM. (Not yet classified by NEMA). Asbestos fabric laminated with melamine resin. Properties same as Grade AA, except better arc, flame and alkali resistance. Available in sheets, rods and tubes.

GRADE G-1. Staple fiber glass cloth bonded with straight phenolic resin. Used where heat and electrical resistance are needed, in combination with higher tensile, flexural, compressive and impact strengths. Better mechanical strength than Grades C and AA. Available in sheets, rods, tubes and molded-laminated.

GRADE G-3. Continuous filament glass cloth bonded with straight phenolic varnish. Somewhat stronger than Grade G-1. Available in sheets, rods, tubes and molded-laminated.

GRADE G-5. Continuous filament glass cloth bonded with melamine resin. Equal to G-3 in mechanical properties, but has superior arc and flame resistance. Available in sheets, rods, tubes and molded-laminated.

GRADE NN. (Not classified by NEMA). Nylon fabric base bonded with straight phenolic resin. Has electrical properties of Grade XXX and mechanical properties of Grade C. Exceptionally good moisture resistance. Impact strength close to that of glass base laminates. Available in sheets, rods and tubes.

GRADE NNP. (Not classified by NEMA). Nylon fabric laminated with a plasticized phenolic resin. Properties equal, but punches and shears better.

Since the laminated sheets are cured between plates, the finish of the sheet delivered by the press depends on the surface of the pressure plates. These plates must be kept clean and free from imperfections, since the finished sheet reflects exactly the character of the surface of the plate. Standard finishes available are as follows:

1. Semi-gloss or polished—Grades XX, XXX, XXM, CE, LE, NN.
2. Semi-gloss only—Grades X, C, CM, L, A, AA.
3. Semi-gloss or dull—Grades XP, XXP, XXXP, AM, AAM, G-1, G-3, G-5, NNP.

All grades are offered in natural color which is a tan. Black is available in all standard grades except XXXP, A and AA. A chocolate brown surface with natural color core is furnished in grades X, XP and XXP. Special colors are available in melamine grades, or in phenolic grades at a higher cost than standard.

Laminated plastic sheets are furnished in these standard minimum and maximum thicknesses:

Grade	Thickness, in., min.	Thickness, in., max.
X, XX, XXM, L, LM	0.010	2
XP	0.010	¼
XXX, LE	0.015	2
XXP, XXXP, NN	0.015	¼
CE, CM	1/32	2
C	1/32	8
A, G-5	3/64	2
AA, G-1	1/16	2

EDITOR'S NOTE: The next article in this series, to appear in the February 1949 issue of PRODUCT ENGINEERING, will discuss specific properties and applications of these materials.

Table I—Properties of High Pressure Thermosetting Plastic Laminates

Grade	X	XX	XXM	XXX	XP	XXP	XXXP	C	CM	CE	L	LM	LE	A	AA	AAM	G1	G5	NN
Materials*	Paper-phenolic resin	Paper-phenolic	Paper-melamine resin	Paper-phenolic resin	Paper-plasticized phenolic	Paper-plasticized phenolic	Paper-plasticized phenolic	Heavy weave cotton fabric-phenolic	Heavy weave cotton fabric-melamine	Heavy weave cotton fabric-phenolic	Fine weave cotton fabric-phenolic	Fine weave cotton fabric-melamine	Fine weave cotton fabric-phenolic	Asbestos paper-phenolic	Asbestos fabric-phenolic	Asbestos fabric-melamine	Glass cloth-phenolic resin	Glass cloth-melamine resin	Nylon fabric-phenolic resin
Tensile strength, psi (1)	14,000	9,000	9,000	7,000	8,000	8,000	7,000	9,500	9,500	8,000	9,000	9,000	8,500	8,000	10,000	10,000	16,000	40,000	7,500
Flexural strength, flatwise, psi (1)	23,000	16,000	16,000	15,000	15,000	16,000	15,000	20,000	17,000	17,000	20,000	20,000	19,000	16,000	20,000	20,000	22,000	42,000	15,000
Compressive strength, flatwise, psi (1)	35,000	34,000	34,000	32,000	22,000	25,000	25,000	38,000	38,000	36,000	35,000	35,000	37,000	36,000	38,000	38,000	40,000	65,000	45,000
Dielectric strength, volts per mil, 0.001 in. (2)																			
short time	700	700	700	650	700	700	650	200	200	500	200	200	500	225	50**	50**	300	450	360
step by step	500	500	500	450	500	500	450	120	120	300	120	120	300	135	30**	30**	225	400	250
Power factor, 10^6 cycles (3)	0.060	0.040	0.040	0.032	0.060	0.040	0.027	0.10	0.10	0.055	0.10	0.10	0.045	0.150	0.150	0.150	0.026	0.020	0.014
Dielectric constant, 10^6 cycles (3)	6.0	5.0	5.0	4.8	6.0	5.0	4.5	7.0	7.0	5.5	7.0	7.0	5.0	7.5	7.5	7.5	5.9	6.5	3.9
Dielectric loss factor, 10^6 cycles (3)	0.36	0.20	0.20	0.15	0.36	0.20	0.12	0.70	0.70	0.30	0.70	0.70	0.22	1.12	1.12	1.12	0.15	0.13	0.055
Water absorption, percent (4)	4.0	1.3	1.3	1.0	3.0	1.3	1.0	3.0	3.0	1.5	2.0	2.0	1.2	1.25	1.5	2.0	1.2	1.5	0.2
Impact strength, Izod, ft-lb per in. of notch																			
flatwise (5)	1.3	1.0	.....	0.80	.....	.....	.....	3.2	3.2	2.3	2.5	2.5	1.8	1.8	3.5	3.5	12.0	16.0	11.0
edgewise	0.50	0.40	0.40	0.35	0.50	0.40	0.30	2.0	2.0	1.3	1.2	1.2	1.0	0.80	3.0	3.0	6.0	8.0	7.0

*For exact compositions, see description in text.
**Over ⅛ in. up to and incl. ½ in. thickness. (1) ASTM D-229-46. (2) ASTM D-149-44. (3) ASTM D-150-45T. (4) ASTM D-229-46. (5) ASTM D256-43T.

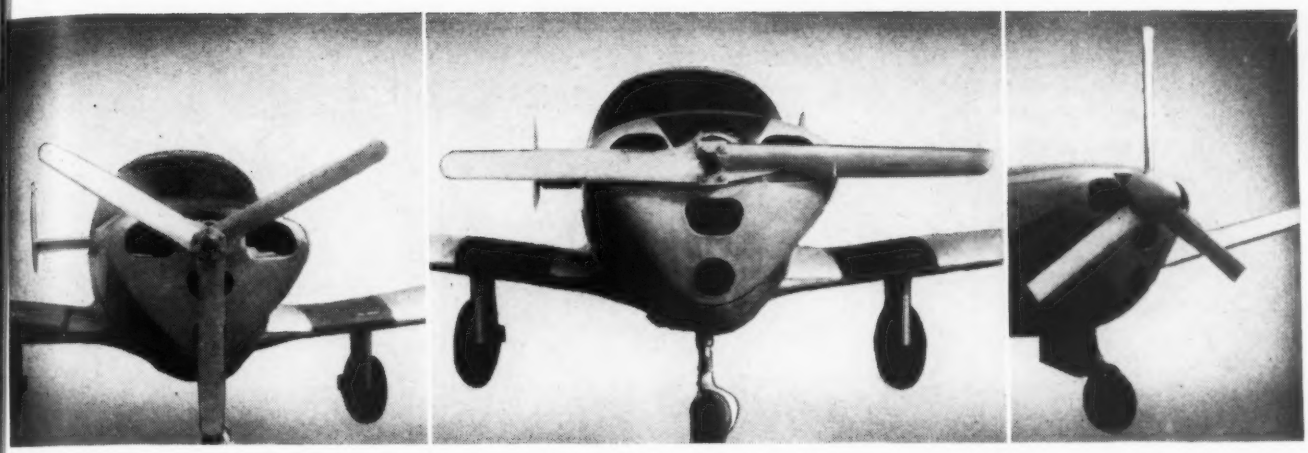


Fig. 1—Extruded propeller blades can be used for three-bladed or two-bladed propellers. Addition of a spinner (right) improves characteristics. Propeller components are held together by steel tubes through which bolts are attached to hub.

Fig. 2—Hub and blade sections, as extruded (right and center), as finished (left), require some machining. Black portion of blade (center) is removed by milling. Leading edge of blade is made heavy to give strength and to serve as attachment to hub.

Extruded Aluminum Propeller Blades and Hub

WALTER H. KORFF
The Korff Aircraft Group

SINCE THE WAR, use of metal propellers for personal airplanes has increased because they are not subject to moisture deterioration and have no blade tipping to loosen. Metallic airfoils, about half as thick as wooden, provide an improvement in aerodynamic efficiency.

Until now, metal propellers have been made from aluminum alloy forgings and have the general appearance of their wooden counterparts. However, they are twice as heavy as, and cost nearly two and a half times as much as, wooden propellers. Extruded aluminum alloy parts cost only half as much per pound as forged parts and the dies required are generally far less expensive.

The two blade propellers shown above with extruded components weigh 4 oz more than a comparable 11 lb wooden propeller and raw material costs are one-quarter as much as for forged aluminum propellers.

An appreciable saving in weight was achieved by reducing the section area near the hub, but to maintain sufficient rigidity, the blade is given a "backbone" along the leading edge. Sections at lower left in Fig. 2 are taken in increments of 6 in. from the hub centerline and show taper of the blade section.

Black portion of the extruded blade in Fig. 2 is removed by high-speed milling; leading edge upper contour is machined with a form cutter, and a flat tapering cut is taken along the under side. The rear leg is milled off except at the hub attachment. Blades are then twisted. Machine cuts are blended into the extruded portion of the airfoil by flexible shaft sanding. Tips can be finished to form either a round or square section.

The hub is cut to length and has a hole bored at the center. The four bolt holes are drilled and reamed on assembly of blades and hub. Steel tubes are pressed into these holes and the assembly bolts are inclosed by the tubes. Blades are slotted and overlap each other at the hub centerline. Each tube and bolt goes through leading edge of one blade and trailing edge of the other. Cost studies of machining operations show that slightly more machining is involved over the conventional forged type but this is more than made up by lower raw material cost.

The blades are made individually and can be used for three-blade designs. The propeller at the left in Fig. 1 weighs 13½ lb; still much less than the 22 lb of forged two-blade propellers.

Three-bladed propellers have three advantages over two-blade: (1) quieter because of reduced tip speed; (2) smoother operation, and (3) minimum diameter—62 in. as compared to 72 in. for usual two-blade propeller.

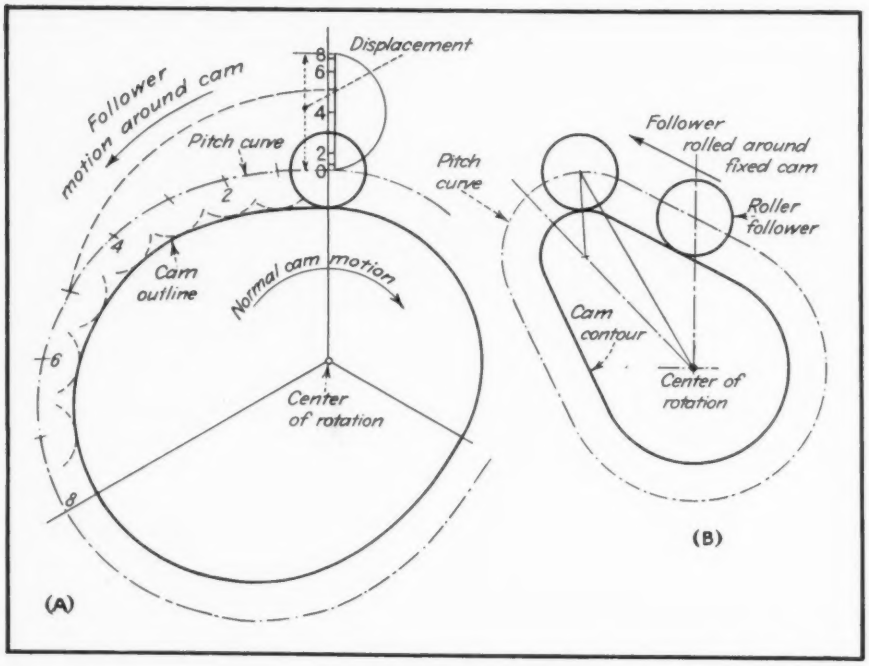


Fig. 1—Conventional graphical methods used in cam layouts. (A) Method for describing the cam contour when motion of follower is prescribed. (B) Method for obtaining the path or the pitch curve of follower when cam contour is the independent variable.

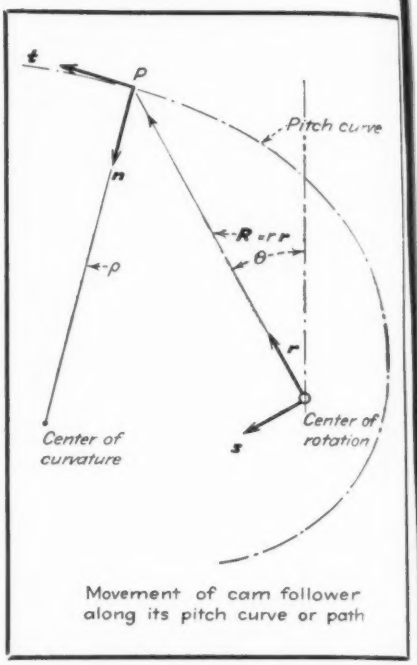


Fig. 2—System of vectors used in the derivation of equations for evaluating velocity and acceleration of the follower.

Accelerations by Vector Methods In Disk Cam Mechanisms

Vector method for determining the accelerations in disk cam mechanisms when the law of motion of the follower is defined by cam contour. An analysis for a mechanism in which the follower has rotation about the cam axis in addition to the radial or oscillatory movement imparted to it by the cam during normal operation.

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VELOCITIES AND ACCELERATIONS in cam mechanisms can be determined by graphical methods to within 5 percent of accurately computed values. This degree of accuracy, comparable to that obtained by slide rule calculations, is adequate for most design analysis. Even in precision cam design, in which the tolerance on the cam contour must be held within a fraction of a thousandth, variations of 5 or 10 percent in the velocity and acceleration rarely are significant.

Disk cams are designed so that their contours may be regarded as either dependent or independent variables. The cam contour becomes a dependent variable if the motion of the follower is prescribed and the outline of the cam must be designed to cause that follower motion. If the contour is selected for ease of construction or of manufacture, and with no more knowledge about the follower motion than the total displacement, then the cam contour represents an independent variable.

Valve cams for automotive engines, eccentric circular disks, and in general the group of cams having outlines that are made up of straight lines and circular arcs, are illustrative of the class of disk cams on which the contours are independent variables. Much of the discussion that follows is applied to cams of this class, inasmuch as the velocities and accelerations of the follower can generally be found directly whenever the law of motion of the follower is prescribed and known.

The conventional method of describing a cam contour when the follower is the independent variable is to hold the cam fixed and to move the follower one revolution around the cam in the direction opposite to that of normal cam rotation. This method of constructing a cam outline for a roller follower that moves radially is shown in Fig. 1(*A*). Simple harmonic motion of the follower has been assumed, with the rise taking place during 120 deg rotation clockwise of the cam.

In like manner, the follower can be rolled around any cam. Fig. 1(*B*) shows the path, or pitch curve, traced by the center of a roller follower in contact with a cam of the second class. This outline consists of two circular arcs joined by straight lines. Motion of the roller center along the pitch curve is the matter of primary interest. Not only is the roller center the point at which the roller is constrained kinematically but it is also the point relative to which the movement of other points in the follower must be referred in order to get their respective accelerations. Many problems are considered solved when the velocities and accelerations of the roller center are determined.

To avoid lengthy equations the ori-

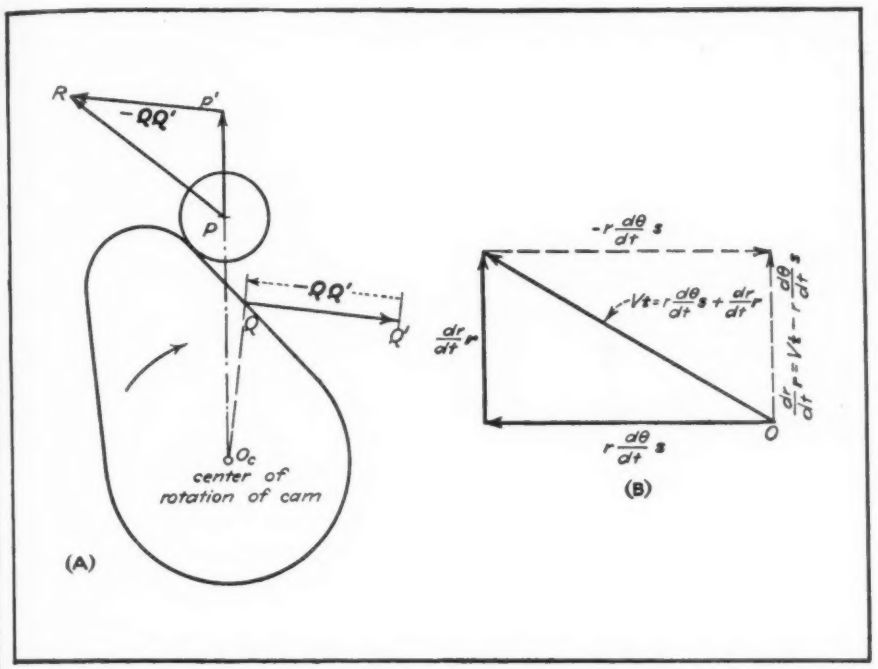

Fig. 3—(A) Principle of adding equal vector quantities or velocities without disturbing the relative velocities. (B) Relation of the vectors before and after addition.

gin for the system of vectors is taken at the center of rotation of the cam, Fig. 2. Let

R=position vector of any point P along pitch curve

r and **s**=unit vectors along and perpendicular to **R**, **s** being taken in the direction of increasing angles θ

t and **n**=unit tangent and unit normal, respectively, at point P on the pitch curve

r=scalar magnitude of vector **R**

V=scalar magnitude of velocity at P along the path

ρ=radius of curvature at P of pitch curve

θ=angular position of **R** with time, the derivative of which is numerically equal to the angular speed of the cam.

In vector notation the position of any point P along the pitch curve is defined by the position vector

$$\mathbf{R} = r\mathbf{r} \tag{1}$$

Since velocity, by definition, is time rate of change of position, the velocity of movement along the pitch curve is given by the first derivative of the position vector with respect to time or

$$\frac{d\mathbf{R}}{dt} = \frac{dr}{dt}\mathbf{r} + r\frac{d\theta}{dt}\mathbf{s} = V\mathbf{t} \tag{2}$$

The acceleration is given by the second derivative of the position vector, that is,

$$\frac{d^2\mathbf{R}}{dt^2} = \left[\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right]\mathbf{r} + \left[2\frac{dr}{dt}\frac{d\theta}{dt} + r\frac{d^2\theta}{dt^2}\right]\mathbf{s} = \frac{dV}{dt}\mathbf{t} + \frac{V^2}{\rho}\mathbf{n} \tag{3}$$

Generally cams rotate at constant speed so that the term $r\,d^2\theta/dt^2$ drops out. The term $2\,(dr/dt)\,(d\theta/dt)$ is recognized as the Coriolis' component. Eq (2) defines a triangle, the directions of the sides being parallel to the unit vectors **r**, **s** and **t** and the length of the scalar coefficient $r\,d\theta/dt$ is known for any point P, assuming the speed of the cam is given. Sides of the triangle parallel to the unit vectors **r** and **s** can always be constructed with accuracy.

Four of the six quantities forming the triangle must be known to fix the other two. Of the three remaining quantities, the unit vector **t** is usually the easiest to establish. Along straight segments of a pitch curve, **t** is parallel to the path so that its direction is accurately established. Along circular segments and along any curve for which the center of curvature is known, **t** is the perpendicular at P to the normal drawn through P and the center of curvature. If the centers of curvature are unknown, then the point of contact of the follower with the cam can be determined and used in the same manner as the center of curvature in establishing the direction of **t**. Vector methods of finding the point of contact are described in the article "Precision Cam Design," p 845, December 1945, PRODUCT ENGINEERING. Drawing **t** by eye tangent to the pitch curve is not a reliable method of establishing its direction, nor as quick as the center-of-curvature method but, with care, **t** can be drawn in this manner with a fair degree of accuracy.

The acceleration, as defined by Eq (3), is expressed vectorially as the hypotenuse of two right triangles. The directions **r** and **s** of one triangle are known. The coefficient of **s** can be computed from data obtained by the solution of Eq (2) and the known or assumed angular motion of the cam. The coefficient of **r** is unknown because the first term of it is undetermined.

In the **t-n** triangle the unit vectors and the coefficient V^2/ρ are positively established if the center of curvature of the pitch curve is available. This condition does not always prevail, particularly on cams for which the pitch curve is defined by prescribing the motion of the follower. The paper "Curvature-Acceleration Relations for Plane Cams" by M. L. Baxter, *ASME Trans.*, July 1948, illustrates a way of finding radii of curvature. Methods of determining radii of curvature are available from the differential geometry of curves and surfaces. A discussion of them is hardly within the scope of this article but might well be the topic of another. On the other hand, reliable accelerations can be obtained from the use of Eq (2) only if the centers of curvature are known accurately; the use of approximate radii or geometrical constructions to establish approximate centers of curvature are not recommended because even small differences are likely to lead to large errors in the accelerations.

Inverting the Motion

In the foregoing analysis the follower has been considered as having all the motion. Ordinarily the cam rotates about a fixed axis thereby imparting to the follower only a reciprocating or oscillatory movement along some straight or curved path. Whether the follower has all or only part of the motion, its motion relative to the cam remains the same. On the contrary, the total velocity and acceleration of a follower moving about the cam differ from its velocity and acceleration when moving back and forth under cam actuation.

To get one velocity from the other, the vector difference of the two is formed. For example, suppose a point Q in the cam has an absolute velocity **QQ'** at the instant the center of the follower has the absolute velocity **PP'**, Fig. 3 (*A*). Now if equal velocities of —**QQ** in magnitude and direction are added to the velocities at P and Q, the relative velocities of the two points remain unchanged, the resultant velocity of Q is nil, and the resultant velocity of P is **PP'** minus **QQ'** equal **PR**. This principle of adding equal vector quantities or velocities without disturbing the relative velocities is also applicable to displacements and accelerations. In dealing with accelerations each point is given a velocity and an acceleration

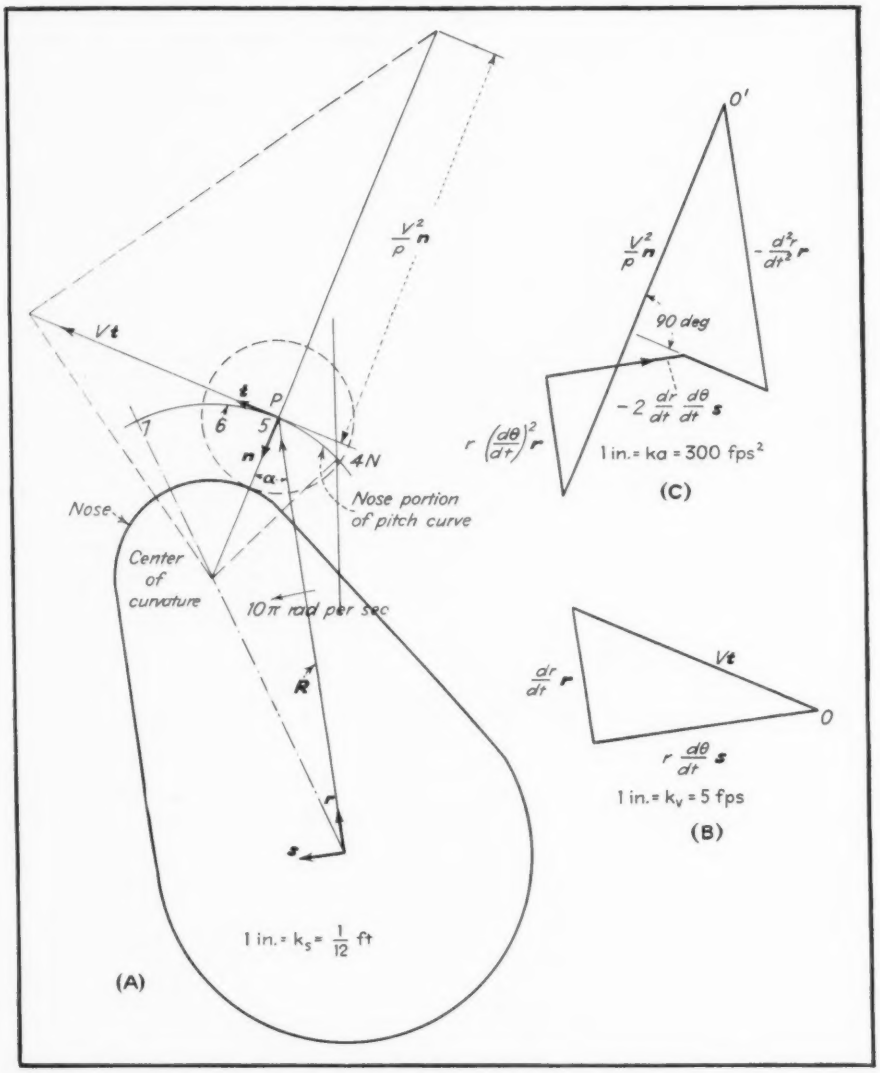

Fig. 4—Graphical method for obtaining velocities and accelerations of a cam follower that moves radially. (A) Position of follower on nose of the cam. (B) Velocity triangle and scalar quantities obtained by measurement. (C) Addition of free vectors.

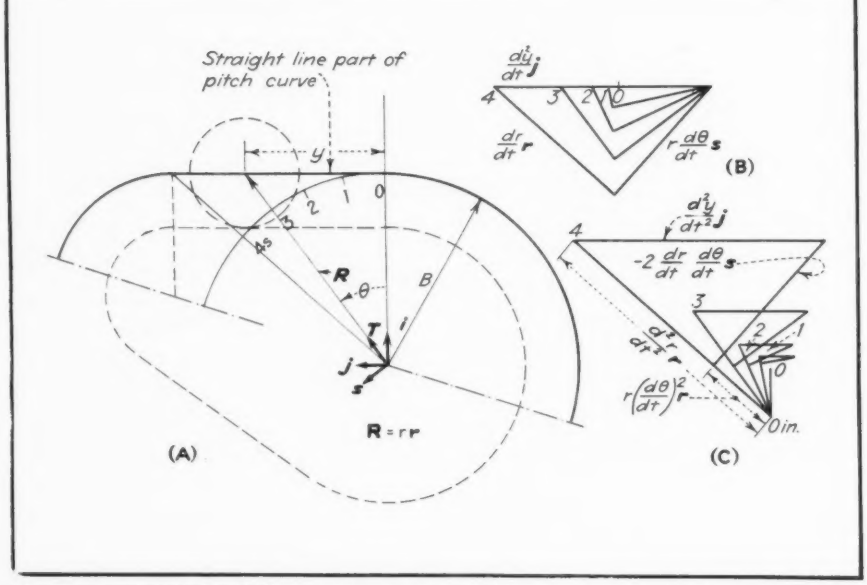

Fig. 5—A method for finding maximum and minimum values of velocity and acceleration. (A) Straight line segment of pitch curve subdivided into four parts for analysis. (B) Corresponding velocity diagrams. (C) Corresponding acceleration diagrams.

equal and opposite to the velocity and acceleration of one of the points.

All that need be done to apply this principle is add equal and opposite vector components to both sides of Eqs (2) and (3). Thus if $-r(d\theta/dt)\,\mathbf{s}$ is added to both sides of Eq (2) there is obtained

$$\frac{dr}{dt}\mathbf{r} = V\mathbf{t} - r\frac{d\theta}{dt}\mathbf{s} \qquad (4)$$

The relation of the vectors before and after the addition are illustrated in Fig. 3(*B*). In many problems the magnitude of the velocity in the radial direction is wanted. This magnitude is given by dr/dt of Eq (4), which can be readily found graphically.

For accelerations the scalar quantity d^2r/dt^2 is generally wanted. Eq (3) can be transposed by adding equal and opposite components of acceleration so as to get

$$\frac{d^2r}{dt^2}\mathbf{r} = r\left(\frac{d\theta}{dt}\right)^2\mathbf{r} - 2\frac{dr}{dt}\frac{d\theta}{d}\mathbf{s} + \frac{V^2}{\rho}\mathbf{n} + \frac{dV}{dt}\mathbf{t} \qquad (5)$$

for the cam rotating at constant angular speed.

An example will illustrate the graphical methods of applying Eqs (4) and (5) to get velocities and accelerations. Suppose a cam, consisting of two circular arcs joined by straight lines, Fig. 4, actuates a roller follower that moves radially. Then the pitch curve is made up of circular arcs and lines parallel to the cam contour. At the junction points between the straight and curved portions the motion undergoes abrupt changes with the change in curvature and consequently the application of Eqs (4) and (5) is adapted to each segment separately.

Scales are important to reliable graphical solutions of problems of motion; hence a few remarks about them might be in order. The writer's practice is to make all measurements on the drawing in inches. An engineer's scale is used so that any measured distance, be it the length of a vector or the dimensions of a kinematic link, is obtained directly in inches and decimals of an inch. The scalar quantity represented by any measured distance is obtained by multiplying the measurement by the scale factor, k_s, k_v, k_a, or k_t, the subscripts s, v, a, and t, referring to space, speed, magnitude of the acceleration and time, respectively.

Conversely, before a scalar magnitude is layed off on the drawing, it is transformed to inches by division by the proper scale factor. Assume, for instance, that an acceleration having a magnitude of 420 fps per sec is to be placed on the drawing to a scale of one

inch equals k_a equals 300 fps per sec. The quotient, or 1.4 in. is the required length. (The scales of Fig. 4 apply to the original drawing before photographic reduction.)

If the cam Fig. 4(A) rotates clockwise at 300 rpm, the angular speed is 10 π rad per sec. A point P located r ft from the center of rotation has a velocity of $-10\ \pi\ r$ s and is represented by a vector $-10\ \pi\ r$ s/k_v. The velocity triangle, Fig. 4 (B) is drawn and the scalar quantities dr/dt and V obtained by measurement.

In like manner the free vectors representing the quantities $r\ (d\theta/dt)^2$ **r**, $-2\ (dr/dt)\ (d\theta/dt)$ **s** and (V^2/ρ) **n** are added, beginning from some convenient origin O', Fig. 4 (C). Since dV/dt is unknown, the vector **t** dV/dt is established only in direction through the terminus of vector **n** V^2/ρ. The closing vector is drawn from O' parallel to **r** to intersect the vector parallel to **t**, thereby defining the scalars dV/dt and d^2r/dt^2. Generally the latter scalar is the quantity wanted.

When maximum and minimum values of the velocity and acceleration are desired, the graphical solution can be repeated for a series of positions to find them. In such analysis, holding the cam fixed and moving the follower about it has advantages. Fig. 5(A) shows how the straight segment might be subdivided for graphical analysis. The corresponding velocity and acceleration diagrams are shown in Figs. 5(B) and (C), respectively.

Since the curvature of a straight line is zero, the equations of motion take simpler forms. They can be obtained from Eqs (4) and (5), or the simplified equations can be derived almost as readily by finding the first and second derivatives of the position vector. If **i** and **j** are fixed unit vectors along the x and y axes, respectively, Fig. 5, the position vector is expressed by

$$\mathbf{R} = r\mathbf{r} = B\,\mathbf{i} + y\mathbf{j} \tag{6}$$

Differentiation yields for the velocity and acceleration the following equations respectively:

$$\frac{dr}{dt}\mathbf{r} + r\frac{d\theta}{dt}\mathbf{s} = \frac{dy}{dt}\mathbf{j} \tag{7}$$

$$\frac{d^2r}{dt^2}\mathbf{r} = r\left(\frac{d\theta}{dt}\right)^2\mathbf{r} - 2\frac{dr}{dt}\frac{d\theta}{dt}\mathbf{s} + \frac{d^2y}{dt^2}\mathbf{j} \tag{8}$$

These equations were used in making the solutions shown in Figs. 5 (B) and (C). Scalar values, as soon as they are found, can be recorded in tabular form for convenience and comparison.

Table I—Scalar Quantities From Solutions of Nose Portion of Pitch Curve

Position	dr/dt, fps	$2\frac{dr}{dt}\frac{d\theta}{dt}$, fps²	$r\left(\frac{d\theta}{dt}\right)^2$,	$\frac{d^2r}{dt^2}$ fps²
4N	14.7	923	425	1544
5	8.7	545	476	1047
6	4.2	264	505	981
7	0	0	514	876

Table II—Scalar Quantities Pertinent to Straight-Line Portion of Pitch Curve

Scalar	Position				
	0	1	2	3	4S
Radius r, in.	3.5	3.59	3.84	4.32	5.18
$k_v r$, ft	0.281	0.299	0.320	0.360	0.431
$rd\theta/dt$, fps	8.84	9.40	10.04	11.3	13.52
$rd\theta/k_v dt$, in.	1.77	1.88	2.01	2.26	2.70
dr/dt, fps	0	1.95	4.4	8.2	14.8
$2\frac{dr}{dt}\frac{d\theta}{dt}$, fps²	0	202	276	515	930
$2\frac{dr}{dt}\frac{d\theta}{dt}$, in.	0.0	0.67	0.92	1.72	3.10
$\frac{r}{k_a}\left(\frac{d\theta}{dt}\right)^2$, in.	0.92	0.98	1.05	1.18	1.41
$\frac{d^2r}{dt}$, in.	0.92	1.15	1.46	2.41	4.80
Scalar acceleration, fps²	276	345	438	723	1,340

Table III—Magnitudes of Acceleration by Graphical Differentiation

Position along straight side	Magnitude of acceleration, in.	fps²	Position on circular nose	Magnitude of deceleration, in.	fps²
0	0.88	286	4N	1.15	375
1	0.99	323	Extrapolated	4.4	1440
2	1.35	440	5	3.38	1100
3	2.33	760	6	2.88	940
4S		−375	7	2.75	895
Extrapolated	4.2	1370			

Tables I and II list values for eight positions during rise of the follower.

Analytical Solutions

Since the foregoing graphical methods are based on purely analytical derivations, analytical solutions to get the magnitudes of the velocity and acceleration are readily made. All that need be done is square the equations to eliminate the perpendicular systems of unit vectors. The resulting scalar equations, with assumed angular positions of the cam, can be solved trigonometrically for the unknown scalars.

Graphical Differentiation

Theoretically the magnitudes of the velocity and acceleration can be found by graphical differentiation of a displacement curve of the follower. Unfortunately, the results are not always reliable and the errors in applying graphical differentiation are likely to be greatest at the junction points where the values may be critical. With reservations, therefore, the magnitudes of velocities and accelerations can be approximated by graphical differentiation, or in a pinch, say a problem in which the centers of curvature are difficult to locate, graphical differentiation might be the sole method available for solving the problem.

To avoid amplifying the errors by two differentiations, the first derived or speed-time curve may better be charted from the velocity equations,

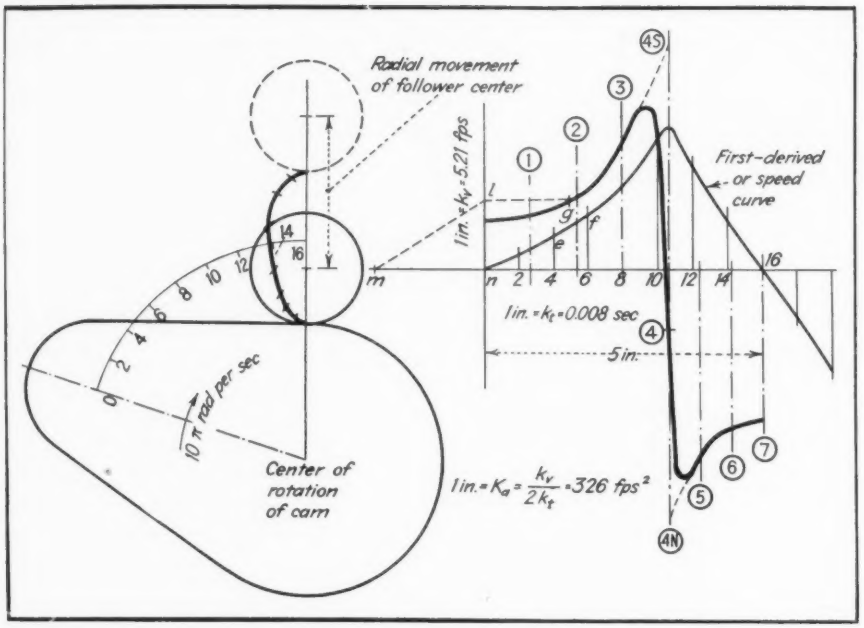
Radial movement of follower center
First-derived or speed curve
1 in. = k_v = 5.21 fps
1 in. = k_t = 0.008 sec
5 in.
1 in. = $K_a = \frac{k_v}{2k_t}$ = 326 fps²
10 π rad per sec
Center of rotation of cam

Fig. 6—Curve representing the magnitude of acceleration is derived from the single differentiation of the speed-time curve. Graphical and analytical values agree closely.

such as Eqs (2), (4) and (7). Fig. 6 illustrates a speed-time curve of the foregoing example plotted in this manner. The single differentiation of the speed-time curve to get the second derived curve or curve representing the magnitude of the acceleration was found as follows: Any convenient pole distance *mn* is chosen. The slope of the chord *ef* approximates the tangent at the midpoint of the arc *ef* so that *ml* is drawn parallel to *ef*. Height *l* projected to *g* locates one point on the second-derived curve.

Other mid-points are found in the same manner. A smooth curve is drawn through them, the ordinates at selected positions measured in inches and multiplied by the scale factor to get magnitudes of the acceleration. The scale factors for speed and for magnitude of the acceleration differ from those on Figs. 4 and 5 because of the influence of pole distances. To get the speed scale, for instance, the space scale k_s is divided by the pole distance *mn* (in inches) times k_t. The time scale, of course, comes from the 300 rpm assumed motion of the cam.

The magnitudes of the acceleration obtained by graphical differentiation to correspond to the points analyzed by the vector methods are given in Table III. Comparison of these tabular values with those in Table I and II shows reasonably good agreement except for the values at the junction point. Knowing how the acceleration behaves at such a point, the curve might be broken into two parts and extrapolated to give more nearly correct values for the acceleration and the deceleration.

Dry Printing Process Operates Electrostatically

A NEW DRY PROCESS called Xerography, utilizing electrostatic principles to take pictures, reproduce drawings and to print on virtually any surface, eliminates the chemical solutions, fumes, negatives and sensitized papers customarily used in printing. Prints made on paper, cloth, wood, metal and other materials can be produced in either black or white or in color and are as permanent as the material on which they are printed. The entire process is completed in less than one minute.

The two principles upon which the process is based have long been known to science. One is the principle of "photo conductivity," or the ability of certain insulating materials to become electrically conductive when acted upon by light. The other is the "triboelectric effect," or the electrical attraction that exists between two dissimilar materials in contact.

A photoconductive plate that corresponds to the film or paper used in ordinary photography consists of an electrically conductive backing material, the face of which is coated with a "photoconductive insulating material." When the coated plate is rubbed with a cloth in the dark, or "sprayed" with electrons, by passing through an electronic corona discharge device, the surface becomes electrically charged within a few seconds. In the charged condition, the plate is sensitive to light.

The sensitized plate is exposed in a camera, under a projection lens, or in a contact printing frame in the same manner that a silvered-emulsion paper is exposed to an image pattern. Whenever light strikes the plate, the coating becomes conductive and discharges the electrostatic surface charge into the backing metal. The surface charge remains on the areas where light does not fall. Thus the image pattern causes a "latent electrical image" to remain on the plate.

Developing is done by flowing specially-prepared developing powder over the plate. This powder is made of two components, one a relatively coarse carrier material, the other a superfine developing resin. The latter can be powdered asphaltum or synthetic resins having low melting points and other desirable characteristics. The powder is attracted to the charged portions of the plate and adheres to those portions tenaciously. The light-affected portions of the plate are unable to retain the powder, leaving it free to roll off. The result is a mirror-reversed positive image of the original subject or copy. This corresponds to the developed negative in silver-emulsion photography.

Printing is accomplished by laying a piece of paper over the powdered plate and charging the paper with the same electronic device used to sensitize the plate. The powder particles relinquish their affinity for the plate and are attracted to the charged paper. By this transfer, the image is restored to its true left-right relationship. At this stage of the process, the print corresponds to the chemically developed silver-emulsion print before it is fixed.

Fixing is accomplished by heating the paper print for a few seconds. Heat melts the powder granules and fuses them to the paper. The fusion temperature is no higher than that ordinarily used for drying or ferrotyping prints.

If the developing powder is black, and the paper upon which the print is made is white, the print will be black and white. Monotone color prints can be made directly by using developing powder that has been dyed the desired color. Multicolor prints can be made by combination prints, using separate plate images for each color.

Determining Dimensional Relationships in Complex Parts

How to determine the dimensions to specify on complex or assembled parts. Seven steps that will lead to lower unit cost and improved part operation.

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Division of Sperry Corporation

THE DIMENSIONAL RELATIONSHIPS between the various sections of a complex or assembled part must be determined in the design stage if the part is to be produced in quantity at minimum cost. Otherwise, some dimensions are assigned tolerances that either are too close or too loose, and the part is impossible or too costly to make. These relationships can be established by algebraic analysis.

The simple relationship shown by Fig. 1 forms the basis for such an analysis. The given dimensions A and B establish the complete lateral dimensioning of the figure since the third dimension, A minus B, is derived from them. Hence, the derived dimension is dependent on the given dimensions for its value. It is also evident that:

$$A = B + A - B \qquad (1)$$

Obviously, A equals A.

If a tolerance is added to each given dimension as in Fig. 2, the same relationship holds true. The derived dimension is now:

$$\left[A\right]^{+a}_{-b} - \left[B\right]^{+c}_{-d}$$

and an equation similar to Eq (1) may be written:

$$\left[A\right]^{+a}_{-b} = \left[B\right]^{+c}_{-d} + \left[A\right]^{+a}_{-b} - \left[B\right]^{+c}_{-d} \qquad (2)$$

When the redundant dimension, B, with the limits plus a to minus b is canceled,

$$\left[A\right]^{+a}_{-b} = \left[A\right]^{+a}_{-b}$$

However, if Eq (2) had not been written and the cancellation made, and a step-by-step procedure were followed as in numerical analysis, a possibility exists that $[B]^{+c}_{-d}$ would be carried along in the arithmetical operations and an erroneous result would be obtained. The subtraction indicated for:

$$\left[A\right]^{+a}_{-b} - \left[B\right]^{+c}_{-d}$$

is performed by changing the signs of the lower set of tolerances and adding these to the upper set in the following manner:

$$\begin{array}{rr} A & +a\ -b \\ & \times \\ -B & +c\ -d \\ \hline \left[A-B\right] & {}^{+a+d}_{-b-c} \end{array}$$

The result is interpreted as two values: a maximum, A minus B plus a plus d; and a minimum, A minus B minus b minus c. Criss-crossing the tolerances makes the operation equivalent to: maximum A dimension minus minimum B dimension, equals maximum A minus B dimension; and minimum A dimension minus maximum B dimension equals minimum A minus B dimension. Then, adding

$$\left[B\right]^{+c}_{-d} \text{ to } \left[A-B\right]^{+a+d}_{-b-c}$$

in a normal manner results in

$$\left[A\right]^{+a+c+d}_{-b-c-d} \text{ instead of } \left[A\right]^{+a}_{-b}$$

Although the relationships of dimensions in a part as simple as that in Fig. 2 are evident by inspection, it is seen that a source of error exists in numerical analyses for complex parts or assemblies where redundant dimensions are not readily recognized.

Basically, an algebraic analysis consists of first writing the equations for the derived dimensions to be found; second, cancelling redundant dimensions in these equations; third, substituting numerical values for the letter symbols; and finally, proceeding with the addition and subtraction of numerals to obtain the values desired. Since the tolerances attached to the terms of an equation are not considered until numerical substitution is made, there is no need to carry these along in the algebraic stages. Thus, a single letter symbol will serve to represent a dimension and its tolerances in an equation. For example, in Fig. 3 each letter represents a nominal dimension and its tolerance, and each rectangle represents a separate part.

Dimension X is established by the following equation:

$$X = A + B - C - D \qquad (3)$$

This equation indicates that three methods may be used to control dimension X. First, any or several of the given dimensions, their tolerances, or both can be changed to obtain the desired value. Second, dimension X can be machined after assembly if changing

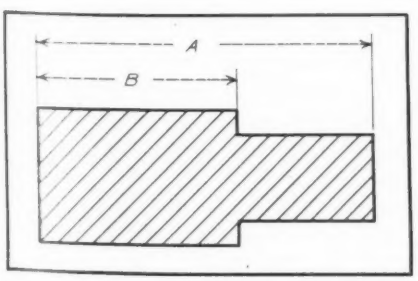


Fig. 1—**Dimensions A and B establish all the necessary lateral dimensions of this part, since the dimension of the unknown section can be established by A minus B.**

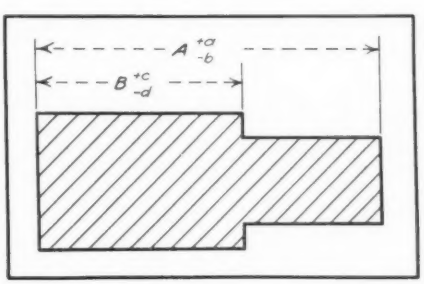


Fig. 2—In this case, unknown dimensions with tolerances also can be derived from given dimensions and tolerances by algebraic subtraction or addition.

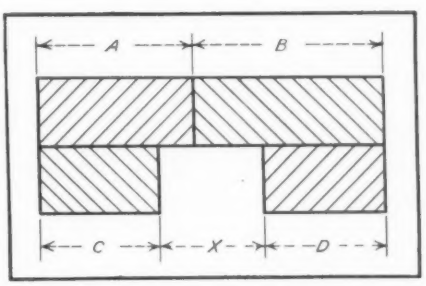


Fig. 3—Quicker dimensional analysis is possible if the known dimensions are assumed to be the nominal values, and tolerances are added afterwards.

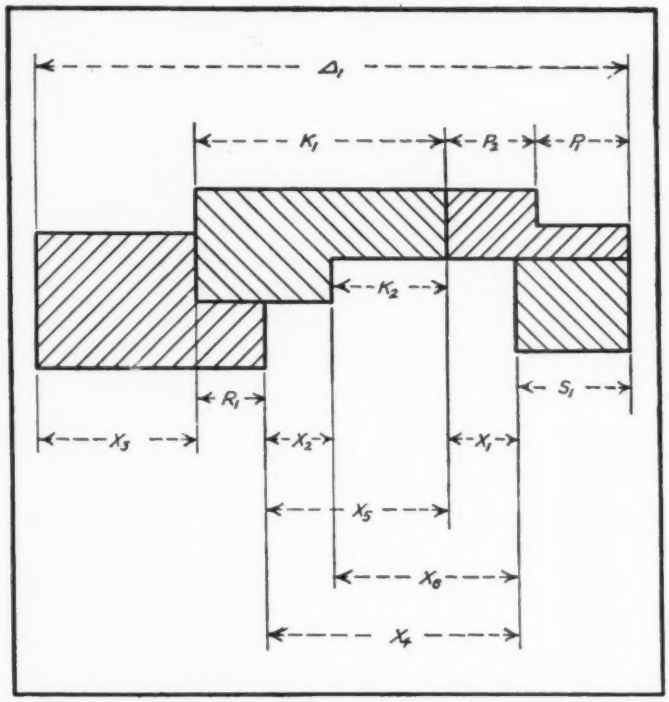


Fig. 4—The basic method of analysis is to assign a capital letter to each part and designate individual dimensions by a subscript. Small letter x with subscripts then represents any dimension derived from the dimensions of two or more parts. Capital Greek letters represent assembly dimensions.

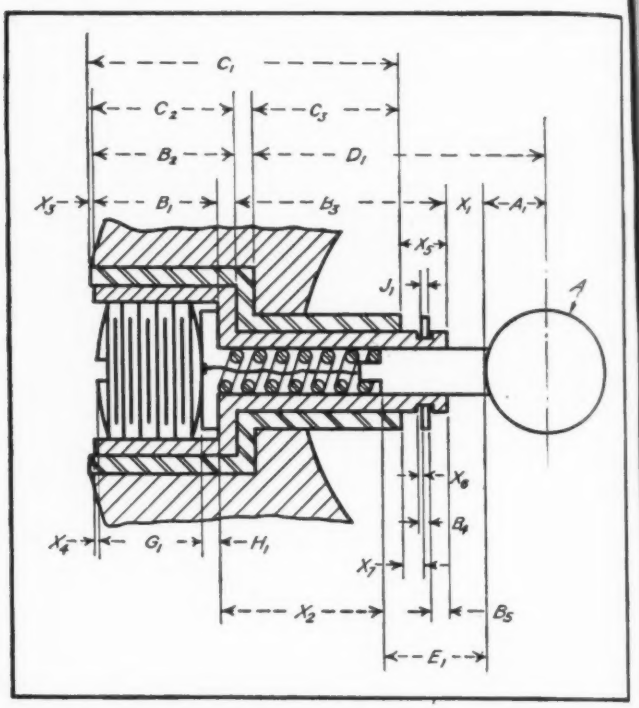


Fig. 5—In this brush holder assembly for an electric motor, dimensions x_1 and x_2 must be held within close positive limits. Lower machining cost results if another dimension C_4 is added to replace C_1 minus C_3, and x_7 may be held within closer limits if B_3 minus B_5 is combined into one dimension.

any of the part sizes is impractical. Third, the design can be changed to permit the dimension to be adjusted at assembly or to combine two or more parts into one and thereby reduce the tolerances that affect it.

This equation is also a valuable aid when a decision has to be made regarding a change in nominal dimensions, or when tolerances have to be changed to control the tolerances of the derived dimension. If it were required, for example, to hold the tolerances of dimension X more on the plus side, the equation shows how this may be accomplished. For example, if the tolerances are added to Eq (3),

$$X = \left[A\right]^{+a}_{-b} + \left[B\right]^{+c}_{-d} - \left[C\right]^{+e}_{-f} - \left[D\right]^{+g}_{-h} \qquad (4)$$

it can be seen that the plus tolerance of X is a plus c plus f plus h and that the minus tolerance is minus b minus d minus e minus g. To increase the plus tolerance of X, a, c, f, or h can be increased; and to increase the minus tolerance, b, d, e, or g, can be increased. These tolerances obviously can be decreased in like manner.

The range of the derived dimension —the algebraic difference between the maximum and minimum values of the dimension—is equal to the tolerance swing. The latter is the algebraic difference between the plus and minus tolerances. This swing is not affected by any change in the nominal values of the given dimensions and can be changed only by changing the tolerances. Varying the nominal dimensions, however, will change the limits of the derived dimension. Both limits will change by the amount of increase or decrease in the nominal value of the derived dimension. Hence, by adjusting the nominal values when numerical dimensions are being used, the limits can be made positive to obtain clearance or negative to obtain interference.

This simplified method of analysis can be extended to complex assembled parts by using a capital letter to designate each part, and by adding subscripts to the latter to represent various dimensions. Small letter x with subscripts then can be used to represent any dimension derived from the dimensions of two or more parts in an assembly. Finally, a Greek letter, such as Δ can be used to designate a given dimension in an assembly.

In Fig. 4, the following relationships are easily established:

$$x_1 = P_1 + P_2 - S_1 \qquad (5)$$

$$x_2 = K_1 - K_2 - R_1 \qquad (6)$$

$$x_3 = \Delta_1 - K_1 - (P_1 + P_2) \qquad (7)$$

$$x_4 = P_1 + P_2 - S_1 + K_1 - K_2 + K_2 - R_1 = P_1 + P_2 - S_1 + K_1 - R_1 \qquad (8)$$

$$x_5 = K_2 - R_1 + K_1 - K_2 = K_1 - R_1 \qquad (9)$$

$$x_6 = P_1 + P_2 + K_2 - S_1 \qquad (10)$$

A study of these equations reveals some interesting facts. The dimension P_1 plus P_2 occurs in Eqs (5), (7), (8) and (10). Since both of these dimensions belong to the same part, they could be combined into a single dimension. This combination would make it possible to hold x_1, x_3, x_4, and x_6, closer because the number of tolerances that affect these dimensions would be reduced by one. If this combination is made, a new dimension, P_3, must be added to replace P_1 plus P_2. But since it is impossible to change the number of dimensions that define a part, either P_1 or P_2 must be retained as the other given dimension. Neither of these appears alone in any equation, so it is immaterial which is retained. The dimension retained will be that which makes for cheaper manufacture. Before making a combination, the change should be analyzed to determine if it will introduce a dimension that will result in increased machining and inspection costs. Consequently, in such a case, it must be decided whether or not the combination is worth making.

The dimension K_1 minus K_2 also may be combined. But K_1 appears alone in Eqs (7), (8) and (9) while K_2 appears alone in Eq (10). It then must be decided whether it is desirable to reduce the number of sets of tolerances that affect x_2 or x_6, or those that affect x_3, x_4, or x_5. If the combination is made, a new dimension K_3 will re-

place K_1 minus K_2. Either K_1 or K_2 must then be retained. If K_1 is retained the number of sets of tolerances that affect the derived dimension in Eq. (10) is increased by one because a new dimension K_1 minus K_3 must replace K_2. On the other hand, if K_2 is retained, a new dimension, K_2 plus K_3, will replace K_1 thereby increasing by one the number of sets of tolerances that affect the derived dimensions in the equations where K_1 appears. In actual cases, a quandary seldom presents itself; derived dimensions that must have small range are evident from the design, and decisions regarding their control are made quickly.

Combining dimensions minimizes the number of terms that affect derived dimensions with close tolerances. Thus, the burden of large accumulations of tolerances is placed on derived dimensions that can vary widely. To reduce the number of given dimensions in an equation containing a group of similar dimensions such as K_1 plus K_2 plus K_3, this group or portion of it should be combined into one dimension provided that no machining or inspection difficulties are introduced. Any dimension that does not appear alone in any other equation, that is not required for constructional purposes, or that appears in another equation whose derived dimension may have its range increased, should be removed.

Inspection of Eqs (5) to (10) shows that a given dimension such as K_1, K_2, S_1, or R_1 may affect several derived dimensions. In view of this fact, a complete analysis should be made before numerical values are assigned.

In Eqs (8) and (9) the cancellation of K_2 resulted in the elimination of tolerances which might otherwise have been added. Had a numerical analysis been made directly, a strong possibility exists that an error would have been made. In a complicated part or assembly, there may be several ways to solve for an unknown dimension. Algebraically, the equation for this dimension will always be the same regardless of the paths followed in deriving it, because cancellation will be made of whatever redundant dimensions are considered. But a numerical analysis in such a case will lead to confusion because there will be one nominal value and several different sets of tolerances for each unknown dimension, only one of which—the value with the smallest tolerances—is correct. When interpreting an equation after an algebraic analysis has been made in complicated cases, first impressions regarding the relationships of dimensions often have to be revised drastically—which further attests to the fact that a correct numerical analysis is difficult to make.

A review of the discussion concerning Fig. 4 leads to the conclusion that from the standpoint of economy, the method of dimensioning a part is a functional operation and that the way a part is dimensioned is determined by its relationship to other parts in an assembly. To be arbitrary in dimensioning may mean the sacrifice of economy, an increase in the time required to produce the part, or may even cause improper functioning of the assembly.

As a practical example of dimensional analysis using the algebraic method, consider the brush holder assembly for an electric motor shown in Fig. 5. It is desirable to control dimensions x_1 to x_7. Dimension x_1 must have a small range because it determines the amount of support brush, E, will have when it has worn; obviously, the tolerance must be held positive. Dimension x_2 indirectly controls the free length of the spring. The range of this dimension determines the variation in the initial compression of the spring. If this compression is too small, the spring pressure will be insufficient when the brush has worn, and if it is too large, the spring pressure will be excessive when the brush is new. In addition, the spring might be overloaded. Hence, x_2 must be held to close positive limits.

Dimension x_3 must be held within moderately close and positive limits. Dimension x_4 should also be held positive but it can be slightly negative if it does not extend beyond the edge of the insulated brush holder, C. Dimensions x_5 and x_7 need only be held loosely positive while x_6 should be held close enough to make sure that the connecting ring, J, will fit its groove. The following equations are evident from inspection of the assembly:

$$x_1 = C_1 - C_2 - C_3 + D_1 - B_3 - A_1 \quad (11)$$

$$x_2 = B_2 - B_1 + C_1 - C_2 - C_3 + D_1 - E_1 - A_1 \quad (12)$$

$$x_3 = C_2 - B_2 \quad (13)$$

$$x_4 = B_1 - G_1 - H_1 \quad (14)$$

$$x_5 = B_3 - C_1 + C_2 = B_3 - (C_1 - C_2) \quad (15)$$

$$x_6 = B_4 - J_1 \quad (16)$$

$$x_7 = B_3 + C_2 - C_1 - J_1 - B_5 = B_3 - (C_1 - C_2) - J_1 - B_5 \quad (17)$$

Because of the manner in which the parts of this sub-assembly are dimensioned, the number of dimensions affecting x_1 and x_2, is large, and a combination of several dimensions appears possible. The first step in this analysis therefore is to reduce the number of dimensions in the equations for x_1 and x_2. The group, C_1 minus C_2 minus C_3 appears in Eqs (11) and (12), and the group, C_1 minus C_2, in Eqs (11), (12), (15) and (17). Although both of these groups appear suitable for combination, further examination of the figure reveals that either combination results in increased machining costs. However, C_3 does not appear alone in any equation, so it can be cast out of the analysis. Three combinations of the three dimensions taken two at a time are possible (a) C_1 minus C_2; (b) C_1 minus C_3; and (c) minus C_2 minus C_3. Of these, only C_1 minus C_3 is possible because minus C_2 and C_3 are not together, and C_3 does not appear in (a). Thus, C_3 can be eliminated by providing a new dimension, C_4, to replace C_1 minus C_3. The group C_1 minus C_2 minus C_3 thus becomes C_4 minus C_2, and part C is then defined by C_4, C_1, and C_2.

At this point, it must be decided whether it is less expensive to hold C_4, C_2, D_1, B_3, and A_1 individually close enough to secure the allowable range of x_1 or whether it might prove less expensive in the long run to introduce a new dimension, C_5, equivalent to C_4 minus C_2. At first it appeared that such a dimension would be costly to machine but now it appears to be more economical than the other alternative. Actually, such a decision must be made with a view to such factors as the method of machining, the number of pieces to be made, and the numerical dimensions involved. The algebraic analysis has served additionally, therefore, in bringing to light a situation which might otherwise have been overlooked. Thus, a decision can be made quickly toward minimizing the cost of the part. If C_4 minus C_2 are combined into a new combination C_5, C_1 and C_2 must be retained, and part C then will be defined by C_5, C_1, and C_2.

Next, the possible combination of B_2 minus B_1, which occurs in the equation for x_2 should be investigated in the same manner as for the C_4 minus C_2 combination. Finally, in Eq (17), B_3 minus B_5 can be combined to obtain closer range for x_7, but this combination is not imperative because x_7 need not be held close. There then remains only the assignment of numerical dimensions and tolerances.

Another practical example, which illustrates the use of the algebraic analysis method in dealing with problems involving clearance holes is shown in Fig. 6. Part C represents a slide that moves along guides, A, which are attached to the block, B, with screws. To insure that the slide does not bind on the guides or that the clearance between them is not excessive, an assembly dimension, Δ_1, is given. With this condition, it becomes important that x_4, the clearance hole diameter, be large enough to admit a

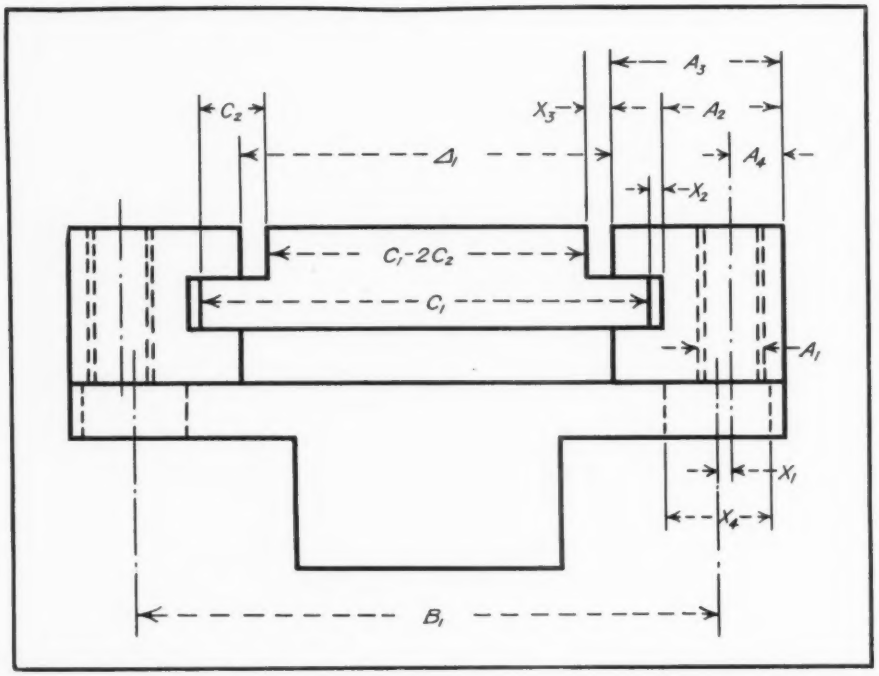


Fig. 6—Algebraic analysis of dimensioning in this slide assembly shows quickly that more economy results from removal of assembly dimension Δ_1, and addition of another dimension Δ_2, which equals Δ_1 plus $2A_3$, minus $2A_2$.

suitable screw. The following equations are derived from Fig. 6.

$$x_1 = \frac{\Delta_1}{2} + A_3 - \frac{B_1}{2} - A_4 \qquad (18)$$

$$x_2 = A_3 + \frac{\Delta_1}{2} - \frac{C_1}{2} - A_2 \qquad (19)$$

$$x_3 = C_2 - \frac{C_1}{2} + \frac{\Delta_1}{2} \qquad (20)$$

$$x_4 = \Delta_1 + 2A_3 - B_1 - 2A_4 - A_1 \qquad (21)$$

Dimension x_1 has been shown for reference only. Since there is no "banking surface" for part C and since the figure is symmetrical, the clearance, x_2, is assumed to be equal on both sides.

In Eq (19), A_3 minus A_2 appears to be a likely combination but since x_2 must be held close a preferable combination would be $\frac{\Delta_1}{2}$ plus A_3 minus A_2. Combining Δ_1, an assembly dimension, with A_3 and A_2 is logical in this case because Δ_1 may be considered a dimension in part A for the purpose of analysis. It is the dimension which would apply if the two parts A were designed as one piece. Thus a new dimension $\frac{\Delta_2}{2}$ replaces $\frac{\Delta_1}{2}$ plus A_3 minus A_2 in Eq (19), and Δ_1 is replaced by Δ_2 minus $2A_3$ plus $2A_2$ in Eqs (18), (20) and (21).

Since x_3 need not be held close, and x_4 may be moderately large no advantage would be gained by attempting further combinations.

Methods of Analysis

The procedure for use of the algebraic method of dimensional analysis resolves into the following steps:

(1). Assigning letter symbols to dimensions of the parts in the layout.

2. Making a sketch of the sub-assembly. In the case of automatic machinery, several sketches may be necessary to show true conditions.

3. Writing the equations for all pertinent dimensions in any one direction. In deriving the dimensions it does not matter what paths are followed because cancellations can be made which leave the final equation free of redundant dimensions.

4. Verifying the derived equations by interpreting the dimensional sense of each on the sketch.

5. Investigating the possibility of combinations in equations where the unknown dimension must have a small tolerance range.

6. Assigning numerical dimensions and tolerances to the letter symbols, remembering that when close tolerances must be held, it is economical to assign more tolerance in the direction of error on the part of the machine tool operator.

7. Adding all the plus values at once, and all the minus values similarly when finding the values of unknown dimensions.

When making a numerical analysis, most designers go through a procedure similar to that outlined above, although not in the same order. They rely on memory to carry the results of each step and in complicated cases, the mind finds the task formidable. There is little need to tax mental processes in dimensioning because the technique, being functional in nature, is amenable to mathematical treatment. In the algebraic method, the designer has a most effective means of securing the greatest possible economy in mass-production from the viewpoint of dimensioning, since it presents the relationships of all dimensions in the form of concise equations.

Beryllium Reduces Porosity of Many Materials

BERYLLIUM CAPPED PISTONS may mean new design headaches, but captured research reports indicate that this use of beryllium in internal combustion engines means longer operating life. A report covering the progress of German and Italian beryllium firms from 1939 to 1945 has been prepared by American Industrialists for the Office of Technical Services, and is now available to industrial personnel.

Methods for capping aluminum pistons with a layer of beryllium one centimeter thick are described in detail. The bonding temperatures range from 800 to 1,100 C. Laboratory measurements indicate that the resistance to wear is excellent.

One section of the report detailing the use of beryllium in refractory manufacture, points out that the resulting products are gas-tight at 1,700 C, and are dense and smooth, resembling fine china. With a melting point of 2,350 C, beryllia crucibles can be used at oven temperatures up to 2,200 Centigrade.

Also described are production methods for the manufacture of beryllium oxide, beryllium chloride, beryllium metal flakes, and both heavy and light beryllium alloys.

The 144-page report was prepared by Office of Technical Services investigator, H. A. Sloman, and C. B. Sawyer, president, Brush Beryllium Company, of Cleveland. It reviews the wartime operations of three German firms, and the Italian firm of Sappi. Copies of the report (PB-2585; "The Beryllium Industries of Germany and Italy") containing flow sheets and drawings of equipment are available from OTS, Department of Commerce, Washington 25, D. C.

Design Factors for Reduction Gears

From "Importance of Design Factors for Marine Reduction Gears" by W. G. Stoeckicht, *Journal of the American Society of Naval Engineers*, August 1948.

IN RECENT YEARS considerable research work has been conducted on stresses in gears. Beam strength, contact stresses and the conditions causing scuffing have been carefully studied. Further investigations are being made dealing with the relation between stresses and endurance. But a contradiction still exists between some theories and as far as their application is concerned, much has been left to the judgment of individual designers.

Stresses derived from contact pressure between two spheres or two rollers can be calculated by means of Hertz' equations. Two meshing teeth can be considered to be two rollers at the contact line. The radii of the rollers are then equal to the radii of curvature of the teeth at the point of contact.

Where

R_c = radius of curvature
R_p = radius of pitch circle
α = pressure angle

at the pitch line, the radius of curvature of each mating tooth is

$$R_c = R_p \sin \alpha$$

This formula clearly shows the influence of pressure angle upon the radii of curvature of a given gear tooth.

Stribeck introduced a new factor for measuring contact stresses, which he called the K factor.

Where

P = load, kg
l = length of line of contact, cm
d_1 = diameter of curvature of one roller, cm
d_2 = diameter of curvature of other roller, cm
d_r = relative diameter of curvature

$$= l/\left(\frac{l}{d_1} + \frac{l}{d_2}\right)$$

for contact of two rollers, the K factor is

$$K = P/l\,d_r$$

The relation between the maximum contact stress in the zone of contact according to the Hertz and Stribeck's K factor for steel is given by

$$P_{max} = 877^2 \sqrt{K}, \text{ kg per sq cm}$$
$$= 3300^2 \sqrt{K}, \text{ psi}$$

In the United States the K factor has been introduced for gears in a modified form that neglects the influence of the pressure angle on the diameter of curvature, which therefore can be used only for the comparison of gears working under the same pressure angle.

In the ball and roller bearing industry, research work investigating the relation between contact stress and fatigue limit has been carried out on a large scale. The results obtained seem to show a clear cubic relation between endurance and the K factor. They may explain why the use of the K factor is more popular than that of P_{max}. If the relation between endurance and the K factor is of the third dimension, then endurance and P_{max} are related in the sixth dimension, and apparently it is easier to solve a cubic relation than a sixth dimension relation when comparing two factors.

The question arises whether the results obtained on roller bearings can be applied to gears. In principle, there ought to be no reason why the material should react differently under contact stresses in gears and in roller bearings. But two points have to be considered.

When two gear teeth mesh, rolling motion is combined with sliding motion, excepting on the pitch line. The sliding motion increases with the increasing distance of the point of contact from the pitch line. Sliding motion under pressure creates an additional tangential force at the point or line of contact.

In a great number of tests by the author on friction gears, where at the point or line of contact both normal and tangential forces are working, he found that the additional tangential forces considerably increased the contact stresses and lowered life expectancy. But in lubricated gears, pitting as a result of contact stresses always begins on the pitch line where there is no sliding motion. From this observation it may be concluded that the influence of tangential forces resulting from sliding motion can be neglected, and that therefore the results obtained from roller bearing tests may also be applied to gears.

The other point of difference is that not all gears are provided with hardened teeth. Where two spheres or two rollers contact under load, very high compressive stresses are obtained according to Hertz' formula. With high specific loads, compressive Hertz' stresses appear to be safe; while the same material would not stand these stresses if the loads were to be applied so as to produce a plain state of stress.

This phenomenon has been explained by the fact that a crystal submerged in a fluid can be exposed to practically infinite compressive stress without altering its structure. This condition exists for parts of the material exposed to the maximum Hertz stresses.

The phenomenon explains why steel of martensite structure shows the best results for taking up Hertz stresses. Load carrying capacity, from the point of view of contact stresses, rapidly decreases with the decrease in hardness of steel. It is believed that the allowable K factor varies as the square of the Brinell or Rockwell hardness of the steel used. An uncertain factor, therefore, must be dealt with in applying the results of roller bearing research to gears with non-hardened teeth. Further with some non-hardened steels, as used in gears with soft teeth, a certain amount of work-hardening is encountered. While it may be said that an established law exists between contact stresses and endurance for hardened gears, this relationship for soft gears is little more than an intelligent estimate.

It seems to be logical that the use of hardened load carrying gears is steadily increasing.

Dealing with the beam strength of gear teeth, the shape of the root fillet is as important as its surface finish, particularly when hardened gears are used. Although the increase of the fatigue limit resulting from proper design and finish of tooth fillets must not be overrated, these improvements probably allow for a more dependable calculation of endurance with regard to bending stresses.

Since the designer is able to calculate more or less exactly the probable endurance of a gear in regard to contact stresses and of beam strength, he is then faced with the problem of how to balance both stresses in his design. This procedure, in general, will lead to the use of a comparatively fine pitch

that from some points of view will be claimed as an advantage. This theory of balance of stresses, with approximately the same numbers of hours of life both for contact and bending endurance, seems to be widely accepted.

The author believes that this rule is entirely wrong. It may give to the calculation of a gear the satisfying aspect of esthetical harmony, but that is all that can be claimed in its favor. The adherents to the rule do not consider two important facts:

1. The equations by which endurance can be calculated are statistical laws, that means the results obtained by the calculation do not represent more than the probability of a certain percentage of accuracy. This scattering in the results is particularly great in the zone of high stresses and, therefore, low values for hours of life.

2. The endurance values for beam strength and contact stresses have an entirely different importance for the safety of a gear and the machinery connected with it.

The basic rule for gear design ought to be that a gear never should fail through tooth breakage. The calculated life expectancy from the point of view of bending stresses ought to be so far greater than the endurance with regard to contact stresses that no gear will have to be replaced for complete breakdown.

In 1931 Hofer published a formula concerning the relation between the surface of a pinion and the number of horsepower it can transmit continuously.

Where

N = horsepower transmitted
D = pitch line diameter, in.
F = face width, in.

Hofer's formula can be expressed as

$$SA \text{ factor} = 3.23\ D\ F / N$$

Hofer said that if the value of the SA factor becomes less than one the pinion will be subject to premature wear. This wear is supposed to result from heat accumulation. He applied his formula to hardened gears. Non-hardened gears will be nearly always on the safe side, because they have rather large dimensions as a result of their comparatively low allowable stresses.

Even considering hardened gears, the problem of applying Hofer's formula as a rule will be encountered in gears operating at high speeds. It has been found that safe performance has often been achieved with SA factors much smaller than one, but there is a great divergence of opinion as to how far one can go. For instance, an SA factor of 0.4 was considered to be safe for some applications.

For many years the author has paid much attention to the extent to which allowable K factors can be influenced by the SA factor. In some cases he has found clear evidence that a very small SA factor was responsible for pitting. With the increasing tendency toward compact designs and high load carrying capacity, particularly in connection with high speeds, Hofer's SA factor may become important for gear design. It is to be hoped that valuable research work may be done with regard to its influence on durability.

Adhesion of Enamel Finishes to Electroplated Cadmium

Foreign Abstract condensed from "The Adhesion of Enamel Finishes to Electroplated Cadmium Coatings" by E. E. Hall, *Metallurgia*, June 1948, pp 75-78.

ORGANIC FINISHES of enamel, paint or lacquer are often applied to electroplated coatings on various metals. When cadmium is used, difficulties are usually encountered with enamel adhesion. Evidence from the test experiences presented here confirms that without chemical pretreatment, cadmium coatings cannot be satisfactorily enameled.

Enamel media employed in these tests were normal commercial varieties, with characteristics as shown in Table I. Plating was ordinary dull cadmium plate deposited from a cyanide electrolite at about 10 amp per sq ft. The thickness of cadmium was 0.0005 in. minimum average, and 0.0003 in. minimum local thickness.

The humidity test consisted of exposure of the panels to a number of daily cycles in which the temperature for an 8 hour day was 55 to 60 C with a humidity of 60-75 percent, and the night temperature was that obtained by cooling down to that of the at-

Table I—Characteristics of Enamel Media used For Tests in Tables No. II to VII.

	Pigmented Cellulose Enamel	Clear Cellulose Lacquer (Special Type)	Stoving Pigmented Enamel	Stoving Zinc Chromate Primer	Stoving Red-Oxide Primer
Type	Heavy bodied grey pigmented cellulose.	Combination glyptal/nitro-cellulose lacquer.	Glyptal-urea synthetic.	Oil modified glyptal synthetic.	Oil modified glyptal synthetic.
Stoving Conditions	— — —	— — —	30 min, 250 F.	30 min, 250 F.	30 min, 250 F.
Composition Percent:					
Volatile Spirit (loss in wt, 3 hours at 110 C)	65.3	90.5	60.5	58.3	45.6
Total Solids	34.7	9.5	39.5	41.7	54.4
	100.0	100.0	100.0	100.0	100.0
Physical Properties:					
Specific Gravity at 25 C	1.013	0.884	1.044	1.039	0.912
Viscosity at 25 C centipoises	750	15	540	320	540

Table II—Typical Aging Tests on Enamel Finishes Under Durability Tests. Cadmium-Plated Steel Panels with and without Passivation, Enamelled with Two Coats of Pigmented Cellulose Enamel.

Chemical Treatment of Cadmium Plate	Exposure Conditions	Condition of Enamel Finish Judged by:		Assessment of Enamel Finish
		Scratch Test	Bend Test	
None	None-initial condition of enamel finish.	Brittle, chipping badly.	Cracks and flakes very easily.	Very poor.
Chromate Passivation	"	Rather brittle, chips.	Cracks and removed easily.	Poor.
Phosphate Passivation No. 1	"	A little brittle, chipping slightly.	No cracking or flaking, very good.	Good.
Phosphate Passivation No. 2	"	Clean cut, no chipping, very good.	No cracking or flaking, very good.	Excellent.
None	Humidity— 7 days.	Chipping and flaking very badly.	Cracking and flaking completely away.	Exceedingly poor.
	" 30 "	"	"	"
Chromate Passivation	" 7 "	Chips rather badly.	"	"
	" 30 "	Chips very badly.	"	"
Phosphate Passivation No. 1	" 7 "	Chips rather badly.	"	"
	" 30 "	Chips badly.	"	"
Phosphate Passivation No. 2	" 7 "	Clean cut, no chipping, very good.	Cracking and flaking easily.	Fair.
	" 30 "	Very slight chipping, still quite good.	"	Fair.
None	Open atmosphere— 30 days.	Chipping and flaking very badly.	Cracking and flaking completely away.	Exceedingly poor.
Chromate Passivation	"	Chipping and flaking.	Cracking and flaking completely away.	Very poor.
Phosphate Passivation No. 1	"	"	"	"
Phosphate Passivation No. 2	"	"	Cracking and flaking easily.	"

Table VII—Extended Tests on Enamel Finished Panels Specimens No. 4 from Tables III to VI Inclusive (Chemical Treatment Phosphate No. 2)

Finish	Further Deterioration When the Test Conditions were Extended to 6 Months	
	Humidity Test	Atmospheric Test
Special clear cellulose first coat, pigmented cellulose enamel top coat	Become very poor	Become very poor
Stoved pigmented enamel, one coat	Very little deterioration	No deterioration.
Stoved zinc chromate primer, stoved pigmented enamel finishing coat	Very slight deterioration.	Exceedingly slight deterioration.
Stoved Red Oxide Primer, stoved pigmented enamel finishing coat	No deterioration	No deterioration.

mosphere with a rise in the humidity to 100 percent, and with moisture condensation upon the specimens.

The scratch test was made using a hardened steel tool, one end of which was tapered to the frustum of a cone, conical angle 15 deg, and dia of the frustum 1/16 in. With this tool a number of scratches were made at oblique angles so as to cross one another. Adhesion was evaluated by the degree of chipping or flaking that occurred, and the ease with which the enamel could be removed from the angle between two such scratches.

The bend test comprised bending the panel slowly through 180 deg with the finished side outwards and the radius of the bend approximately $\frac{1}{8}$ in.

Table II deals with pigmented cellulose enamel finishes. The only useful finish is represented by Sample No. 4 with phosphate passivation No. 2. None of the finishes showed any real permanency and it is concluded that ordinary cellulose enamel finishes are unsatisfactory on a cadmium plate base.

Table III (This and following tables from original are not reproduced here) deals with a cellulose finish in which the first coating is a clear lacquer. Only specimens treated with phosphate passivation No. 2 retain a sufficient standard of quality to be regarded as satisfactory.

Table IV deals with an enamel finish comprising a synthetic coat of stoved synthetic enamel. Sample 4 is the only satisfactory one.

Table IV deals with an enamel finish comprising a synthetic coat of stoved synthetic enamel. Sample No. 4 is the only satisfactory one.

Table V covers panels using the same enamel finish but using a stoved synthetic zinc chromate primer.

Table VI covers a similar series of panels, only the primer is a red oxide synthetic, with the synthetic enamel finishing coat.

As in all previous tables, only the samples having chromate passivation or phosphate passivation No. 2 are good.

The samples from these tests that were still satisfactory at the end of the 30 day test were left under test for six months more and then reassessed. They all comprised samples having phosphate passivation No. 2.

Results are given briefly in Table VII, shown here.

The treatments were as follows:

Chromate—plated work was taken directly from the washers after plating and treated by immersion 10-15 sec at room temperature in a solution containing 200 g of sodium dichromate crystals and 6.6 mls of concen-

trated sulphuric acid per liter of water. The treated work was washed in cold water and air dried at a temperature not exceeding 140 F.

Phosphate—treatment No. 1. Applied using a solution of zinc nitrate, sodium phosphate, phosphoric acid and nitric acid, adjusted to a suitable concentration and acidity.

Phosphate—treatment No. 2. Used one commercial phosphate process having a nitric acid accelerator with immersion time of 3 min at a temperature of 180-185 C.

After treatment in these phosphate solutions, the work was washed in hot water and rinsed for 15-30 sec in a solution of chromic acid at 170 F, this chromate rinse being prepared from ½ lb of chromic acid in 100 gal of water.

The phosphate treatment No. 2 is simple to operate and control, and is entirely satisfactory on all types of cadmium coating. The film formed, however, is electrically insulating. If this is objectionable, electrical contact can be made by breaking the film.

Aircraft Plastic Laminates

From "Use of Plastic Laminates in Air Force Aircraft—Part I", by R. T. Schwartz, W. G. Ramke and J. K. Lang, Air Materiel Command, Wright-Patterson Air Force Base, presented at the Low Pressure Seminar of the Society of the Plastics Industry, June 29-30, 1948, Washington, D. C.

APPLICATIONS made by the Air Force of low pressure plastic laminates are important. The principal applications are: (1) Radio and radar antenna housings, (2) backing for self-sealing tanks, (3) ducts for cold and hot air, and (4) honeycomb core materials for sandwich constructions.

The plastic laminated material principally used for these applications is glass fabric base polyester resin laminate. Some use is also made of low pressure phenolic laminating resin for these applications; cotton fabric is combined with glass fabric in tank backing material and cold air ducts; nylon fabric is coming into use for backing material, both laminated with polyesters and also with nylon. Honeycomb cores are usually made of glass fabric-polyester laminate and of cotton fabric-phenolic laminate. The applications listed make use of straight laminate, except that most of the radar antenna housings (radomes) and some of the radio antenna housings, are sandwich constructions, employing a honeycomb or low density plastic core. Since these antenna housings are now integral parts of the aircraft, flush with the exterior surface, they are important structural aircraft parts. Some of the radomes are relatively large and occupy an important percentage of total area.

Glass fabric-polyester laminates are used because of their good strength-weight ratios, low water absorption, excellent weathering resistance, good electrical properties, and their relative ease of fabrication into large or small parts of compound curvature. However, there is a definite need for improvement of some of these properties.

Plastic backing material is used in the form of flat sheet to separate the self-sealing fuel tanks from the metal aircraft structure and to support the tanks. Projectiles passing through metal causes the metal to flower out, and if no plastic backing is used, this will hold the "wound" in the tank open and prevent sealing. The plastic prevents the flowering of the metal from penetrating the tank. The ducting systems in aircraft are complicated and are difficult and expensive to make accurately from sheet aluminum. The low pressure laminated plastic ducts are advantageous from ease of fabrication, less costly, ease of joining sections together, and easier to install due to ability to maintain tolerances. Because of minimum gage requirements in case of the metal ducts, the plastic ducts can be made lighter. There are also disadvantages, such as elevated temperature limitations and inflammability.

The necessity for the use of a non-metallic material for antenna housings is obvious. The structural advantage of sandwich construction are relatively well known, but sandwich construction is used for radomes because of the excellent radar transmission characteristics. Low pressure laminated polyester glass fabric honeycomb core material (as well as other low density core materials) is used with polyester glass fabric laminate faces. Cotton fabric base phenolic plastic honeycomb core material with aluminum alloy faces is used to some extent for small subsonic missile wings.

Many experimental parts of low pressure laminated polyester-glass fabric plastic have been and are being made and tested. Helicopter tail and main rotor blades are being tested in which a core of low density balsa wood is wrapped with glass fabric impregnated with polyester resin then cured at low pressure. Small low horsepower propeller blades are being tested which have been made the same way. The helicopter and propeller blades have a metal covering on the leading edge for protection of the plastic against rain erosion and sand abrasion. Possible advantages of the plastic propeller blades over laminated wood blades are better moisture resistance and durability, and better aerodynamic efficiency, because plastic blades can be made thinner than the wood, since they are stronger. Compared to metal propeller blades for these small sizes, the plastic blades can possibly be made lighter and less expensive.

Normal atmospheric temperature range for aircraft applications is approximately —70 to +160 F, and this is the range applicable to plastic laminates used in subsonic aircraft, except for those applications subjected to elevated temperatures, such as hot air ducts or parts located so that they are heated by the aircraft power plant. For both production and experimental applications it is necessary to know the basic strength properties of the materials at room temperature and how they vary over the previously mentioned atmospheric temperature range. These properties include stress-strain and ultimate strength in tension, compression, shear, bending, torsion, and bearing. Moduli of elasticity and rigidity and Poisson's ratios will be necessary. Also desired are fatigue and impact data.

The Air Materiel Command is sponsoring projects at various institutions to obtain the strength properties at elevated temperatures of the most heat resistant of the presently - available polyester, silicone, and phenolic low pressure glass fabric laminates, including tension, compression, bending, creep-rupture, and fatigue tests. Materials development contracts are being sponsored on improved heat resistant low pressure silicone laminates and on low pressure phenolic laminates.

Data obtained to date indicate a marked difference in mechanical properties at elevated temperatures between various commercially available polyester laminating resins all laminated at low pressure with the same glass fabric. The most heat resistant of these polyesters will withstand temperatures up to 300 F for long periods without deterioration, and the strength at 300 F ranges from 20 to 40 percent of the room temperature values. At temperatures above 300 F, the polyester laminates deteriorate and delaminate on sufficient time of exposure (200 hr or less). However, these same materials will withstand short time exposure at temperatures up to 500 F for at least ½ hr, and the short-time strength at 500 F is approximately 10 to 20 percent of the room temperature value. No data can be given as yet on low pressure silicone and phenolic laminates, although it has been reported that continued exposure at approximately 500 F does not deteriorate certain high pressure silicone glass fabric laminates.

TECHNICAL NEWS

SENDING—film containing message is placed in scanner that produces electrical impulses for transmission as radio waves.

RECEIVING—messages are reproduced as television images on tube in cylinder at upper right. Camera records images.

Communications System Sends Million Words a Minute

ULTRAFAX, a newly developed system of television communication capable of transmitting and receiving written or printed messages and documents at the rate of a million words a minute, was recently demonstrated by the Radio Corporation of America at the Library of Congress in Washington.

The system is a joint development of RCA Laboratories and the RCA Victor Division, with the cooperation of the Eastman Kodak Company and the National Broadcasting Company. It combines the magic of television with the latest techniques in ultra-high frequency radio relaying and photography. It surpasses other forms of radio communications as well as wire telegraph, cables and air mail, through its ability to transmit at radio speeds exact facsimile reproductions of all material to be serviced. Its capacity for handling graphic communications is indicated by the fact that it can service such assorted material as letters and telegrams, including signatures, drawings and maps, magazine illustrations, sections of newspapers, cartoons, advertising layouts, tables of instruction and business and financial documents. It also can handle musical scores, weather maps and foreign language messages written in Chinese.

The remarkable speed of transmission results, in turn, from each of three key factors of the invention. First, the great velocity of radio transmission; second, the ability of television to transform pages of information for transmission as television pictures at the rate of thirty per second, and third, high-speed film processing or "hot photography" which delivers a single frame of film ready for printing or projecting in forty-five seconds, as compared with forty minutes by conventional processes.

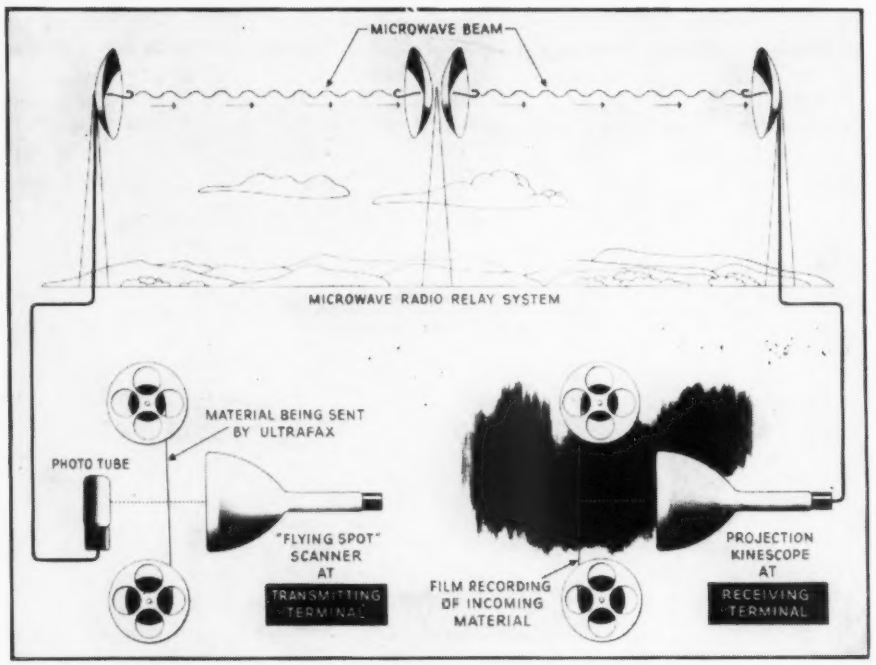
The Ultrafax system can be adapted readily to handle either full-page copy or microfilm recordings prepared in advance. The experimental sending terminal (upper left) utilizes microfilm recordings.

When the system is fully developed, the service may be available at communications centers placed strategically in metropolitan and suburban areas. Once in the sending terminal, the message would be placed on a conveyor that would carry it to the central transmitting room containing a "flying-spot" television scanner.

At the heart of the electronic scanner is a cathode-ray tube or kinescope. By means of it, each tiny area of the message is examined and electrical impulses generated to indicate the degree of light appearing on its surface. The funnel-shaped tube has a flat glass end or screen coated with fluorescent material that glows as the electron beam strikes it. This beam of light is deflected back and forth thousands of times a second. By means of a lens, the beam is imaged on the copy to be transmitted. When film recordings are used, the beam passes through the lens and film to strike a phototube in a light-tight housing. The small vacuum tube responds to the variations in light intensity by generating electric currents that become radio signals at the transmitter.

Passage of the film through the optical gate for scanning is achieved without the intermittent motion required in a movie camera. The lens is simply focused and the scanner placed in operation. The engineer operating the unit is able to observe on monitoring equipment the condition of the successive messages as they flash across the screen. He can also check waveforms on an oscilloscope.

Although the kinescope in the scanner requires a high-voltage power supply, it can be operated without risk. From the engineering standpoint, it is regarded as a simple unit using power


MICROWAVE BEAM
MICROWAVE RADIO RELAY SYSTEM
MATERIAL BEING SENT BY ULTRAFAX
PHOTO TUBE
"FLYING SPOT" SCANNER AT TRANSMITTING TERMINAL
FILM RECORDING OF INCOMING MATERIAL
PROJECTION KINESCOPE AT RECEIVING TERMINAL

SCHEMATIC diagram of Ultrafax microwave transmission communications system.

at radio frequencies instead of sixty cycles. An accelerating voltage of approximately 30,000 volts is available at the output. The signal can be radiated by either a broadcast-type television transmitter or by microwave radio relay circuits.

Signals reaching the receiving antenna can be fed by coaxial cable to the Ultrafax receiving terminal. This complicated apparatus converts the electrical wave into a modulated light spot on the face of the receiving kinescope. Adjustments of the deflection circuits can be made by the operating engineer as he watches a monitor and sets gain and brightness controls. The electron spot moves back and forth over the sensitive screen on the face of the kinescope tube and produces a single bright line trace. Intensity varies from instant to instant in exact synchronism with the light and dark portions of the picture at the transmitter.

The lens of the camera beneath the receiving kinescope can be adjusted to focus incoming images on the film inside. The Ultrafax camera itself is much simpler than the type generally used for motion pictures, since it requires no mechanism to produce an intermittent motion. When the driving motor is started, the film comes up immediately to its proper operating speed, moving unexposed film continuously from the supply spool past the lens system.

At the end of transmission, the exposed film is transferred to a processing unit in which, under darkroom conditions, it is passed through a miniature developing tank. In this machine the film is developed and fixed in less than fifteen seconds and dried in twenty-five seconds. The processor, as used in experimental Ultrafax transmissions, has handled film at a rate as high as thirty-two messages per minute.

By means of an Airgraph enlarger, Ultrafax messages recorded on 16 mm film can be blown up to full-page size. The film is threaded through an optical projection unit of this continuous process machine, and sensitized paper moves on a roll within focusing distance. The image of each message or frame is projected down on the gate beneath which the photopaper passes. Exposure is lightning fast, making possible the recording of thousands of words every second.

Mr. D. S. Bond of the RCA staff coordinated the television, radio and facsimile research, while Dr. Kenneth Mees of Eastman developed the recording equipment.

Radio Telescope Taps Sounds of Invisible Stars

A NEW RADIO TELESCOPE was recently demonstrated at Cornell University. Instead of registering the light of distant stars and galaxies invisible to the human eye, it "tunes in" on the radio waves recently found to be constantly transmitted from celestial bodies.

The "mirror" of the telescope is a 204 in. saucer-shaped radio reflector and is thus four inches larger than the 200 in. optical mirror of the Hale telescope atop Mount Palomar.

The cost of the radio telescope was about $30,000, as compared with $6,000,000 for the Mount Palomar "eye." Unlike the optical telescope, it can be operated in cloudy weather, as radio waves penetrate clouds as well as haze.

Since radio waves of the range of frequencies transmitted by the Milky Way, the sun and other parts of the universe can also penetrate clouds of cosmic dust that make large areas of space opaque to optical telescopes, the new radio mirror promises to open a new and much wider "window" into the vastnesses of space.

Designed to withstand winds up to 60 mph and to track with an angular error of less than one-half a degree, the telescope will see areas of the sky whose diameter varies from about two to thirty degrees, depending on the frequency utilized.

In addition to the usual astronomical polar and declination axes, two other rotations are available, one about a vertical axis to facilitate calibration of the antenna; the other, the rotation of the 17 ft parabolic reflector about its own axis for polarization studies.

The information from space is received from a sensitive receiver fed by a small antenna at the focal point of the reflector.

Electric Eye Controls Street Lights

AN ELECTRONIC "EYE" that is able to "see" dusk and dawn approaching, and turn individual street lights on or off, has been developed by engineers at the Lynn, Mass. plant of the General Electric Company.

This photo-electric control device will be installed on single street lights, whereas most automatic time-control devices now in use turn a series of street lights on and off at a predetermined time.

A gas-filled phototube, sensitive to red light, is used as the "brain" of this automatic lamp-lighter. This is done because the light rays of the sun in early evening occur at the red end of the color spectrum.

The individual photo-electric control unit, including the phototube and the amplifier tubes, can be plugged into a single street light equipped with a plug receptacle. A small window, shielded from the direct rays of the setting or rising sun, will face toward the north and receive the light impulses, so that the street light will go on shortly before darkness and off just as dawn breaks.

Washington Notes

Supersonic Wind Tunnel Exhausts Air to Atmosphere

A supersonic wind tunnel reported to be largest in the world was unveiled by the National Advisory Committee for Aeronautics at the newly named Lewis Memorial Laboratory in Cleveland.

Test section of the new tunnel is eight ft high and six ft wide. It is designed for testing full-scale models of turbo-jets and ram-jets up to Mach 2 under conditions of temperature and pressure equivalent to flight conditions at 35,000 ft. This new tunnel compares with the six by six ft test section at NACA's Ames (Calif.) Laboratory designed to test aerodynamic shapes up to Mach 1.6.

Unusual feature of the Cleveland tunnel is discharge of its air from the test section into the atmosphere. Most wind tunnels recirculate their air. Contamination and increase in water content resulting from operation of jet engines within the tunnel make it impractical to recirculate the air in this equipment. Air from the tunnel is discharged through a large conical diffuser fitted with an exhaust muffler to reduce noise.

The Cleveland tunnel also features an adjustable throat with two stainless steel side walls automatically flexed to the desired width by means of hydraulic jack screws. The flexible throat makes it possible to vary the speed of the air flowing through the test section.

The tunnel is powered by three electric motors coupled on a single shaft to provide a total of 87,000 hp. Motors drive an 18 ft dia, seven-stage axial flow compressor at speeds from 770 to 880 rpm. The compressor has more than 1000 blades.

Air for the tunnel is drawn through the largest air dryer to be built in this country. It is capable of drying 2,200,000 cfm down to a dew point of —10 F by passing through beds of activated alumina. Heated air passed through the drying beds for several hours at a time reactivates the alumina.

Giant Testing Machine Developed for Navy

BUILT TO NAVY specifications by the Baldwin Locomotive Works, the world's largest testing machine having a capacity of 5,000,000 lb was recently demonstrated at the Aeronautical Structures Laboratory in the Philadelphia Navy Base. Though the giant machine was developed for testing the lightest weight aluminum and magnesium structures that aeronautical engineers can design, it can be used by designers of heavy structures and machinery in every field for obtaining accurate design data.

Acceptance tests indicated an accuracy within ¼ percent over six ranges down to 0 to 24,000 lb. Load variations of only 5 lb can be measured. Test specimens up to 30 ft high, 50 ft long and 10 ft wide between columns can be subjected to stresses in tension, compression or flexure. The hydraulic loading cylinder is 54 in. in diameter and has a stroke of 36 in. Testing speeds range up to 3 ipm, return speed is 15 in. per minute.

The load measuring system consists of an Emery cell carried by the crosshead, a Tate-Emery indicator with two dials, and accessories located in the cabinet beside the machine. Flexible tubing conducts pressurized fluid.

Synthetic Quartz Developed

Quartz has been produced synthetically in high grade quality under sponsorship of the Signal Corps. Engineering Laboratories.

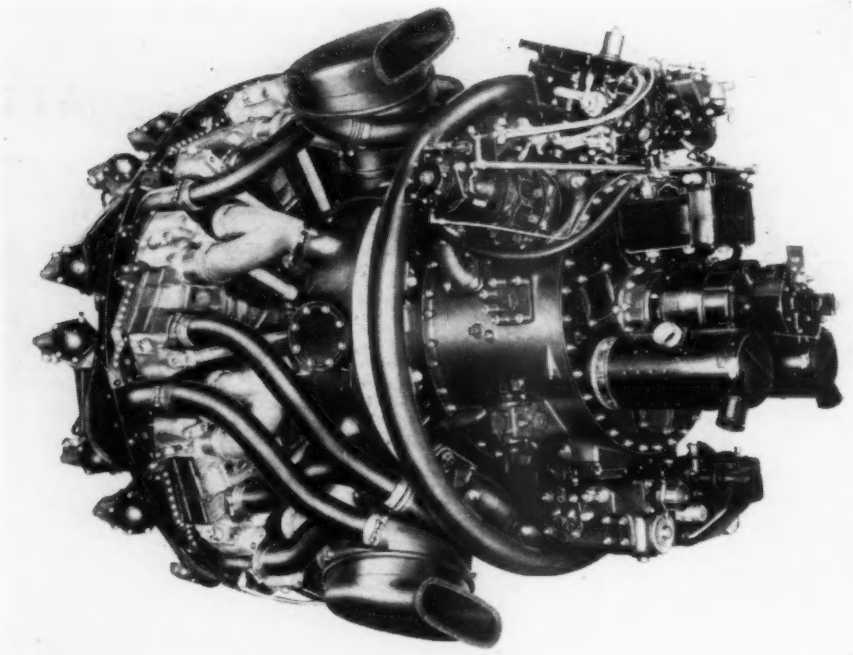
Recently, the Brush Development Co. of Cleveland, Ohio, delivered the largest single crystal known to have been produced from any artificial source. The greatest dimensions of the sample are equal to the diameter of a silver dollar.

Crystals are grown by deposition from a solution containing the raw material derived from quartz-sand or other silica materials, in a closed metallic container maintained at a temperature of about 750 F, and at pressures as high as several thousand times that of the atmosphere.

Individual molecules are deposited on a seed crystal in a regular manner to produce a larger outward geometric expression of the inner structure of the original seed. As long as the material solution is supersaturated, the surplus material, while under controlled conditions of pressure and temperature, will deposit layer on layer in a regular manner to build up the final crystalline form, much as building blocks are used to make rectangular structures.

Turbines Boost Piston Engine Power

The Army and Navy have placed contracts with United Aircraft's Pratt



THREE "blow-down" turbines recover approximately 20 percent of available heat energy normally exhausted from stacks. Engine is Wright's new Turbo-Cyclone.

& Whitney Division and Curtiss Wright's Wright Aeronautical Corporation for the development of two types of compound aircraft powerplant. Both engines incorporate turbines that utilize exhaust gas energy to increase the power output.

Pratt & Whitney have combined the General Electric CHM-2 two-stage turbosupercharger with their 28-cylinder Wasp Major to produce the new R-4360-VDT powerplant. The GE unit performs two functions—it supercharges the engine's combustion air and discharges gases to the rear through an adjustable orifice, producing jet action. Operation at altitudes above 40,000 ft can be achieved and an increase of 800 lb thrust is produced.

Engineers of the Wright Aeronautical Corporation have added three "blow-down" type velocity turbines to the 18-cylinder R-3350 engine. Each turbine is turned by the exhaust gases from six cylinders and the energy recovered is geared back directly to the engine crankshaft. Delivered horsepower of the new Turbo-Cyclone is thereby boosted about 20 percent without increasing the fuel consumption.

Standard Tool Plan Adopted by NSRB

A program geared for rapid mobilization of machine tool and certain key equipment production capacity is being completed by the National Security Resources Board.

Stand-by or "ghost" orders are being placed with 290 manufacturers whose ability to produce specific types of machine tools has been found, through cooperative investigation, to be adequate.

By placing these orders in the hands of the manufacturers, NSRB believes that between six months and a year would be saved in case of an emergency, thus avoiding a severe bottleneck similar to those that developed before World Wars I and II.

A breakdown of the 100,000 tools most needed by the military has been made according to types and sizes. Plant capacities were then surveyed on a 40-hour basis and tentative production schedules for specified machines were sent to approved manufacturers.

Each manufacturer is being asked for comments regarding ability to produce and need for accessories required for the machine tools under consideration. Adjustments are being made on the basis of these comments and the final stand-by order is being set up and sent to the manufacturer for filing. No specific commitments are being made regarding costs of the tools. These figures are to be determined by the manufacturer's published price lists at the time of emergency.

Orders will be revised at least once a year to prevent obsolescence and to keep abreast of new tool needs as improved weapons and changes in design appear.

Machine tools are not the only items for which pool orders are being established. Studies are now under way on gages, abrasives, cutting tools, mechanical and hydraulic presses and hammers, materials handling equipment, industrial furnaces and ovens, foundry equipment and supplies, and several other special plant equipment categories. Also, in the "thinking" stage for pool orders are the following: Antifriction bearings, wood working equipment, and some general industrial equipment.

Lightweight Salvage Pontoon Developed

SALVAGE and flotation problems encountered during the Bikini Atom Bomb test resulted in the development by the Goodyear Tire & Rubber Company of 25-ton capacity, lightweight salvage pontoons that resemble a pumpkin. This fluted construction was adopted to allow for the extreme pressure variations that occur as the pontoon rises to the ocean's surface.

The pontoon has a hollow center that traps air. Heating of the center by the sun's rays causes this air to expand and exert pressure on the outer covering. This covering is synthetic rubber coated nylon fabric having a high tensile strength that provides a watertight and airtight chamber. Cables encased in heavy rubber hose are attached to a fitting at the top of the bulb and spread out around the conical body of the pontoon. The hose prevents the cables from biting into the fabric.

The 25-ton units are so designed that they can be attached in tandem to provide a 75-ton lifting load in one spot.

Fire-Resistant Hydraulic Fluid Developed for Aircraft

SKYDROL, a fire-resistant hydraulic fluid for use in aircraft has been developed by the Douglas Aircraft and Monsanto Chemical Companies. Described as a synthetic liquid combining most of the desirable characteristics of existing hydraulic fluids with fire-resistant qualities never before attained, material will contribute to the safer operation of modern air transport.

Notable characteristics of the new fluid, in addition to its fire-resistant qualities, include a viscosity index of 160, providing a minimum change of viscosity over a wide temperature range down to —40 F, and a lubricity proven to extend the life of pumps and other moving parts.

"Give us the tools . . ."

For High Wages, Full Employment . . . Business Must Have Better Tools *and More Money to Pay for Them*

So far we have escaped the post-war depression predicted by leading government economists. How can we continue to frustrate gloomy prophets who see only depression ahead?

At the end of World War II the federal Director of Reconversion saw depression immediately ahead. He said we would have 6,000,000 unemployed four months after VJ-Day and 8,000,000 a few months later.

But we did not have depression. We did not because:

First, the American business man, sensing the obligations of a vastly more important post-war America, went ahead to build his plant and equipment to meet expanding domestic and world markets—markets bigger actually and potentially, in terms of world-wide trade and profits than any previously envisaged.

Second, the American businessman was able to get the money to go ahead. Since 1945 he has spent $50 billion building new plants and buying new equipment.

There may be other reasons why we missed a depression in 1946. But—make no mistake about it—what has powered our present prosperity is the $50 billion spent by businessmen since VJ-Day to improve their plants.

It provided jobs directly for 5 million people. It paid for more than half of our record-breaking steel output. It put in place the foundations of great new industries such as television. It strengthened the foundations of the chemical, machinery, plastics, steel and oil industries. It has expanded and improved our power systems throughout the country.

This spending has made the difference between prosperity and slump, between industrial strength and serious deterioration.

In fact, we know now that what business spends for new plants and new tools always makes the difference between prosperity and slump, the difference between national strength and weakness.

The accompanying chart tells the story. When we have spent heavily for new plants and equipment, we have had prosperity and strength. When we have not, we have been in trouble.

We would have been in trouble since VJ-Day except that business used its war reserves, plus two-thirds of its profits, plus borrowed money to improve and expand its facilities. This year industry is spending $19 billion this way.

Has this great post-war expansion actually made our economy a "mature economy"? Have we come now to the saturation point the New Dealers mistakenly said we had reached in the '30's?

The answer is no!

Proof of that answer is being developed through a McGraw-Hill national survey of "Business' Needs for New Plants and Equip-

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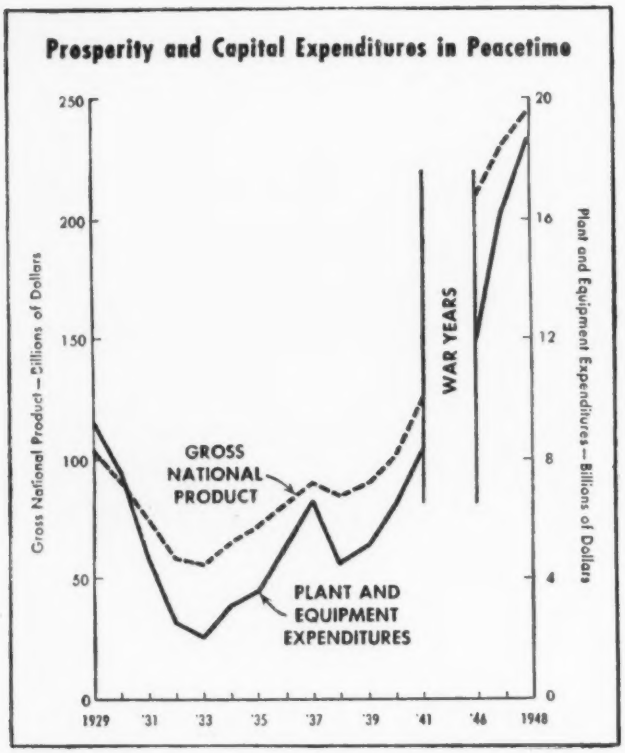

ment" details of which will be given in this editorial series in coming months.

We have a bigger nation, more people, to serve right here at home. Further we must meet human needs which the war created around the world. Also, we must sustain a world position such as this country never assumed before.

Here are immediate things crying to be done.

1. Business still needs billions to expand production because our country and our needs are growing rapidly. Example: To meet the demand for power, electric utility companies must nearly double their present generating capacity in 10 years. That will cost more than $7.5 billion. To fill increasing needs for oil and gasoline, oil companies must spend at least as much.

2. Business still needs billions to get its plants up to date and overcome wear and tear. Examples: Over half a million of our freight cars, a third of the total, are more than a quarter of a century old. About two-thirds of the looms in the textile industry are more than 20 years old. Half of our coke ovens, basic equipment for iron and steel production, are more than 20 years old, and only half as efficient as modern ovens.

3. Business still needs many billions to do new things in dramatic new ways. Example: Machinery that will cut out 80% of the dirty, dangerous work of mining soft coal has been perfected. A new automobile engine plant will reduce the work that goes into engine-building by three-quarters.

Hundreds of similar things that our scientists and engineers have developed could be cited. They can be found in every industry. They hold immeasurable promise of adding to the abundance of American living. In fact, there is hardly a step along the whole route of industry—from roughing out raw materials to delivering finished goods—where there are not new and better ways of doing things standing ready for general use.

But the crucial question now is: Where is the money coming from to put to work these new and better ways of doing things?

Business has used its own resources so far... profits and reserves. The stock market, where industry traditionally has raised money from people willing to risk their savings, has been limping along, giving business no chance to get enough money on satisfactory terms. *Business now must look primarily to its own earnings for the money to carry out the improvements which are necessary if America is to keep itself strong and efficient.* The next editorial in this series will deal with this new and crucially-important role of profits.

But business can not count on profits alone to do the job. Profits are too uncertain.

From now on finding the money... to put new ideas and new equipment to work... to go ahead with the expansion and improvement that will thwart depression and build industrial strength *. . . calls for the support of all Americans everywhere.*

This comes right down to *you... for at stake is your chance for steady work, for better pay, for new things like television, and for more of the every-day things, like coal and clothing, of better quality and at less cost.*

By helping business get new and better tools, you will help yourself—and you will help build a more sound, more prosperous, better America.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

MEETINGS

November 28–December 3
AMERICAN SOCIETY OF MECHANICAL ENGINEERS — Annual Meeting, Hotels Pennsylvania and New Yorker, New York, N. Y.

November 29–December 4
NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING—Grand Central Palace, New York.

December 2–4
SOCIETY OF EXPERIMENTAL STRESS ANALYSIS—Annual Meeting, Hotel Commodore, New York, N. Y.

December 1–2
AIRCRAFT INDUSTRIES ASSOCIATION —Air Force-Navy Industry (ETC) meeting on accessory oil seals, Washington, D. C.

December 3
MAGNESIUM ASSOCIATION — Quarterly Meeting, Mellon Institute, Pittsburgh, Pa.

December 5–9
AMERICAN SOCIETY OF REFRIGERATING ENGINEERS — 44th Annual Meeting, Statler Hotel, Wash., D. C.

December 6–8
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Conference on Electric Welding, Engineering Society of Detroit Bldg., Detroit, Mich.

December 14–15
AIRCRAFT INDUSTRIES ASSOCIATION —Air Force-Navy-Industry meeting on accessory drive requirements. Power Plant Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio.

January 10–12
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Conference on High Frequency Measurements, Wash., D. C.

January 10–14
SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting, Book-Cadillac Hotel, Detroit, Mich.

January 10–14
MATERIALS HANDLING INSTITUTE—Materials Handling Show, Convention Hall, Philadelphia, Pa.

January 12–14
SOCIETY OF THE PLASTICS INDUSTRY, REINFORCED PLASTICS DIV.—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

January 19–21
SOCIETY OF PLASTICS ENGINEERS—Annual Meeting, Bellevue-Stratford Hotel, Philadelphia, Pa.

TWO NEW SOCIETY PRESIDENTS are Harold K. Work (right) of the American Society for Metals and Thomas D. Jolly (left) of the American Standards Society. Dr. Work is Director of Research at Jones and Laughlin Steel Co. and a member of the Executive Committee of the Engineering and Industrial Research Division, National Research Council. Mr. Jolly is Vice-President in charge of Engineering and Purchases at the Aluminum Company of America and a member of ASME.

Process Equipment and Methods Stressed at Metals Show

THE 30TH ANNUAL METAL CONGRESS and Exposition held October 23 to 29 in Philadelphia highlighted the 75th anniversary of the development of alloy steels. The congress was jointly sponsored by the American Society for Metals; the American Institute of Mining and Metallurgical Engineers, Metals Division; the American Welding Society and the Society for Non-Destructive Testing. The outstanding developments among the 300 exhibits centered around processing methods and machines.

Two new developments in the welding process field were featured by the Air Reduction Sales Co. and Linde Air Products Company. Air Reduction's Aircomatic process is a development of the inert gas-shielded arc welded process. A pistol-type gun is used and aluminum wire is fed automatically through the barrel from a coil on the control box. Wire feed range is from 100 to 300 ipm. Gun can be used in any position, and welds are clean, free from spatter and show excellent penetration.

Linde's new arc spot welding process is a variation of the Heliarc method. Equipment consists of a small plastic pistol weighing several ounces. The trigger is pressed and the gun held in place for several seconds until the arc is extinguished. No forging pressure or backup are necessary. Spot welds can be made from one side of the work at locations previously inaccessible with conventional equipment.

Alan Wood Steel Company of Conshohocken, Pa., announced a new abrasive-impregnated steel plate possessing excellent non-skid properties.

In the testing field, Tinius Olsen exhibited a universal testing machine with electronic strain and load measuring devices. Machine is especially applicable to plastics and other flexible materials. The Baldwin Locomotive Works featured their new load cells that are finding increased applications for measuring compressive forces electrically in number of fields.

American Cladmetals Company of Carnegie, Pa., demonstrated a variety of commercial products fabricated from

CAST CRANKSHAFT, made of Meehanite Metal, is 18 ft long and weighs over 5,000 lb. Used in a large marine diesel engine, casting has a tensile strength of 71,000 psi and a Brinell hardness of 280.

Rosslyn metal, a stainless steel sheet containing a copper core. This core, permanently bonded by a special process, provides extremely rapid and uniform heat conductivity.

Authorities in the nonferrous metals field stressed the trend toward the extrusion of aluminum, brass and bronze.

New Data on Jet Steel

RESULTS of recent research on sigma phase, a brittle compound formed by certain alloying atoms in steel subjected to high temperature, are expected to influence the metallurgy of high-temperature materials.

Studies reveal that the more cold working (rolling, hammering and drawing) the metal receives, the greater and more rapid will be the formation of the sigma phase. It was also discovered that the presence of a structure called delta ferrite increases measurably the sigma phase formation.

The investigation was conducted at Illinois Institute of Technology by Dr. Otto Zmeskal, director of the metallurgical engineering department; Dr. Pun Kien Koh, Associate Director of Research at Allegheny Ludlum Steel Corporation's Tool and Die Steel Division; and John J. Gilman, Campbell Fellow at Columbia University.

Ceramics Replace Glass In Radio Tube

A RADIO TUBE of ceramic materials capable of producing radio waves few inches in length. The tube tech nique developed utilizes an alloy silver and titanium to unite the part The alloy is so strong that if th bonded piece is broken, the break oc curs in the ceramic and not in the join

The soldering process is accom plished at high temperature in vacuum which effectively drives ou the gases in the metal and ceram parts, thereby simplifying final evacu tion of the tube.

Foreign Reports from McGraw-Hill World News

Industrial Designers' Society Formed in Australia

A Society of Designers for Industry, operating on the lines of the American Society of Industrial Designers and of the British Council of Industrial Design, has been established in Australia.

Full membership is limited to industrial designers who give professional service in determining the form and outward character of manufactured products, with particular consideration to methods of manufacture and the function of the design.

Among the objectives of the Society are the promotion of a wider understanding of industrial design among manufacturers and the public and the coordination of joint projects with educational institutions.

British Plastics Industry Being Expanded

Teflon, a development of Du Pont will be produced by Imperial Chemical Industries Ltd. in accordance with a reciprocal agreement between the two companies. I.C.I. which developed polyethylene during the war and made it available to the U. S. through Du Pont is thus getting a return on its investment.

Imperial is making Teflon as a molding powder, but only in small quantities on a pilot-plant scale in the company's General Chemicals Division in Lancashire. The factories are at Widnes and Runcorn near Liverpool.

British Mechanical Products Ltd. have announced that they are making use of this polytetrafluorethylene material for a number of applications where its high heat resistance and other desirable properties such as moisture resistance, are required.

This company is molding the plastic into radio tube holders, cathode-ray tube-holders, wave guide components, condensers and resistors all of which will find wide use in airborne radio and radar equipment where temperatures are extreme.

New Turbine Blade Material For Gas Engines

For some years the standard turbine blade material used in all British gas-turbines has been Nimonic 80, a nickel-chrome alloy developed and trademarked by Mond Nickel Co. and produced by Henry Wiggin & Co. Ltd., of Birmingham. But it has been evident that high-speed aircraft like the DH.108 and the Glouster Meteors of the RAF High-Speed Flight have been utilizing turbine blades made of a material having a load-carrying capacity greater than that of Nimonic 80 alloy products.

First details of a new turbine blade material designated 80A are announced by Mond Nickel Co., who did the research. This material, which is superior to Nimonic 80 in that it can be used for relatively short-time service in a temperature range up to 820 C, also has an increased load-carrying capacity at lower temperatures. This improved performance has been obtained without sacrificing other desirable properties such as the capacity to resist oxidation and corrosion.

The heat-treatment of both Nimonic 80A and 80 consists of a solution treatment for eight hours at 1,080 C, followed by an aging treatment of 16 hrs at 700 C; air is the preferred furnace atmosphere. During this extended period at high temperature, an altered superficial layer with a maximum thickness of 0.003 in. is produced. This layer should be removed by machining or other means before th component goes into service.

Both alloys are adversely affected b cold work, the effect being an in creased rate of creep under given con ditions. This leads to failure by rup ture in a shortened time at a larg elongation. The alloys begin to me at about 1,380 Centigrade.

Forging of Nimonic 80 and 80 can be satisfactorily performed in th range from 1,050 to 1,150 C. Be cause of the rapidly increasing stiffnes of this material below 1,000 C, fre quent re-heatings are necessary, and i forging turbine blades, it has bee found advisable to apply one or, i the most, two blows, between re-hea ings. The furnace atmosphere shoul be oxidizing and fuel used should hav a low sulphur content.

Russia Establishes Institute For Study of Business Machines

The Academy of Sciences of th USSR has established a new Institute of Precision Mechanics and Calculat ing Technique that is designed to serve as a national experimental-research center for machine mathematics. This action was taken to meet a need created by wide development of this branch of Soviet research.

Institute members are to determine accuracy of mechanical and electrica systems, principles of mathematica machines, design and methods for solv ing problems on these machines.

An associate of the new institute says Soviet scientists are designing and constructing improved machines that will solve complex mathematical prob lems rapidly. Application of calculat ing machines to the country's business activity is yielding substantial saving in time and labor.

Nomograph for Designing High Speed V-Belt Drives

K. D. LEWIS
Merco Centrifugal Company

THE DESIGN OF A V-BELT DRIVE for the normal installation requires only a simple selection from manufacturers' catalogs. However, in specifying drives where belt speeds must run over 6,000 ft per min, information is not readily attainable.

Calculation of the tight side tension, which includes the important factor of centrifugal tension, can be used as a guide for comparison in designing such drives.

This type of drive should include an automatic tension adjustment to maintain constant tension on the belts, and an indicator should be provided for reading the actual running tension applied to the belts. Running tension should be just above that necessary to carry the load (just above the tension at which slip will occur) as any further increase decreases belt life while any less will cause excessive heating and subsequent failure.

The nomograph that follows has been found useful for quick computation. It is based on the following equations where

N = rpm of driven sheave
M = rpm of driving sheave
d = pitch dia of driven sheave, in.
D = pitch dia of driving sheave, in.
S = belt speed, ft/min
W = belt weight, lb/ft
g = gravity constant, 32.2 ft/sec/sec
HP = horsepower transmitted per belt
α = arc of contact, radians
T_c = centrifugal tension, lb
T_1 = tight side tension, lb
T_2 = loose side tension, lb
T_r = min recommended running tension, lb
R = ratio of tight side to loose side tension (neglecting centrifugal tension) $R = \dfrac{T_1 - T_c}{T_2 - T_c}$

$$N = \frac{DM}{d} \tag{1}$$

$$S = \frac{\pi d N}{12} = 0.262\, dN = 0.262\, DM \tag{2}$$

The mass acting to produce T_c is half of the mass projected on a diameter. General form of the force equation is

$$T_c = mrw^2$$

where

$$m = \frac{1}{2} \times \frac{W}{g} \times \frac{d}{12}$$

$$r = \frac{d}{2 \times 12}$$

$$W = 2\pi N$$

Then

$$T_c = \left(\frac{1}{2} \times \frac{W}{g} \times \frac{d}{12}\right)\left(\frac{d}{2 \times 12}\right)\left(\frac{2\pi N}{60}\right)^2$$

$$= \left(\frac{\pi d N}{12}\right)^2 \frac{W}{3{,}600\, g} = 8.63 \times 10^{-6}\, WS^2 \tag{3}$$

$$Tr = T_1 + T_2 - 2T_c \tag{4}$$

$$HP = \frac{2\pi NT}{33{,}000} \text{ (General Form)}$$

$$T = \frac{(T_1 - T_2)\, d}{2 \times 12}$$

$$HP = \frac{2\pi d N\,(T_1 - T_2)}{2 \times 12 \times 33{,}000} = \frac{S\,(T_1 - T_2)}{33{,}000} \tag{a}$$

$$R = \frac{T_1 - T_c}{T_2 - T_c} \tag{b}$$

From (b) $T_1 = R\,(T_2 - T_c) + T_c$ (c)

From (b) $T_2 = \dfrac{T_1 - T_c}{R} + T_c = \dfrac{T_1 - T_c + RT_c}{R}$ (d)

Combining (a) and (c)

$$HP = \frac{S\,(RT_2 - RT_c + T_c - T_2)}{33{,}000}$$

$$= \frac{S\,(T_2 - T_c)\,(R - 1)}{33{,}000}$$

then

$$T_2 - T_c = \frac{33{,}000\, HP}{(R - 1)\, S} \tag{e}$$

Combining (a) and (d)

$$HP = \frac{S\,(RT_1 - T_1 + T_c - RT_c)}{33{,}000\, R}$$

$$= \frac{S\,(T_1 - T_c)\,(R - 1)}{33{,}000\, R}$$

then

$$T_1 - T_c = \frac{33{,}000\, RHP}{(R - 1)\, S} \tag{f}$$

(continued on page 157)

ENAMEL
VEGA CHROMOXIDE
FORMVAR
COTTON
SILK
PAPER
BARE COPPER
TINNED COPPER
Magnet Wire by...
AUTO-LITE
Engineered For Your Job
Manufacturers can secure magnet wire in every shape, size, type and insulation at the big Port Huron plant of Auto-Lite. Available, too, is the essential engineering know-how that comes from long experience and forward-looking research. For full information about the "Right Wire for Your Job," write to
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TUNE IN "SUSPENSE," THE AUTO-LITE RADIO SHOW—THURSDAY NIGHTS, 9:00 P. M.—E. T. ON CBS

Adding (e) and (f)

$$T_2 - T_c + T_1 - T_c = T_1 + T_2 - 2T_c$$

$$= T_r = 33{,}000 \left(\frac{R+1}{R-1}\right) \frac{HP}{S}$$

For drives with automatic tension and 180 deg arc of contact, R should be held at 8. For other arcs of contact, R may be computed from

$$R = \text{Antilog } 0.288\ \alpha$$

Nomograph is plotted from α equals 150 deg for which R equals 5.66, this value being chosen as a safe estimate for most drives.

For other arcs of contact, multiply values of T_r obtained from nomograph by

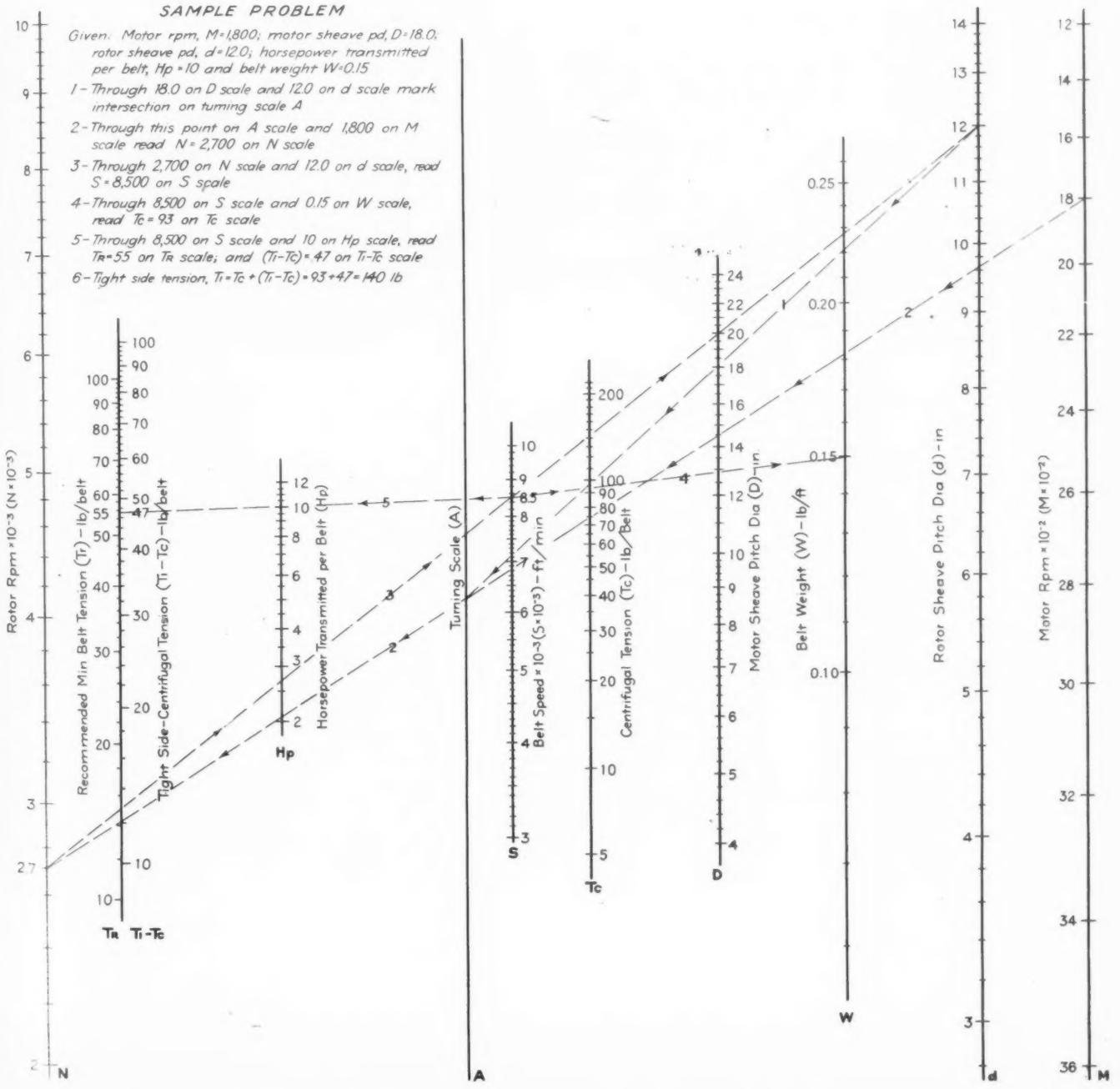
$$0.70 \left(\frac{R+1}{R-1}\right)$$

Equation f from (4) gives

$$T_1 - T_c = \frac{33{,}000\ RHP}{(R-1)\ S} \qquad (5)$$

T_1—T_c is plotted on nomograph for an arc of contact of 150 deg. For other arcs, multiply (T_1—T_c) obtained from graph by

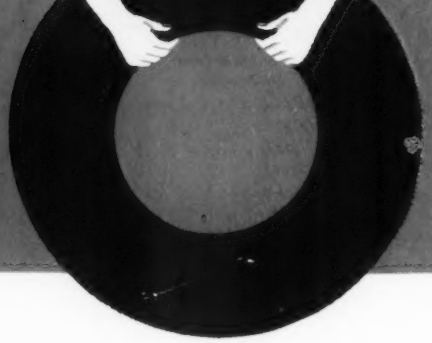
$$0.823 \left(\frac{R}{R-1}\right)$$


SAMPLE PROBLEM
Given: Motor rpm, M=1,800; motor sheave pd, D=18.0; rotor sheave pd, d=12.0; horsepower transmitted per belt, Hp=10 and belt weight W=0.15
1-Through 18.0 on D scale and 12.0 on d scale mark intersection on turning scale A
2-Through this point on A scale and 1,800 on M scale read N=2,700 on N scale
3-Through 2,700 on N scale and 12.0 on d scale, read S=8,500 on S spale
4-Through 8,500 on S scale and 0.15 on W scale, read Tc=93 on Tc scale
5-Through 8,500 on S scale and 10 on Hp scale, read TR=55 on TR scale; and (Ti-Tc)=47 on Ti-Tc scale
6-Tight side tension, Ti=Tc+(Ti-Tc)=93+47=140 lb
Rotor Rpm×10⁻³ (N×10⁻³)
Recommended Min Belt Tension (Tr)-lb/belt
Tight Side-Centrifugal Tension (Ti-Tc)-lb/belt
Horsepower Transmitted per Belt (Hp)
Turning Scale (A)
Belt Speed×10⁻³ (S×10⁻³)-ft/min
Centrifugal Tension (Tc)-lb/Belt
Motor Sheave Pitch Dia (D)-in
Belt Weight (W)-lb/ft
Rotor Sheave Pitch Dia (d)-in
Motor Rpm×10⁻² (M×10⁻²)
TR
Ti-Tc
Hp
S
Tc
D
W
d
N
A
M

R/M FRICTION MATERIALS

RANGE FROM THE SMALLEST

TO THE LARGEST



Top: Friction element used in textile machinery.
Bottom: Friction disc used as a flange on cable reels.

Looking for a small clutch facing for a high-speed machine tool? **You'll find it in the R/M line!**

Looking for a huge brake block for a drag line or a mine hoist? **You'll find this, too, in the R/M line.**

Whatever the size or shape of the friction material you want...whatever its frictional characteristics...R/M probably has it already, or something mighty close to it. R/M brake and clutch materials are made in dimensions from a fraction of an inch in width to 44 inches in diameter. In composition, these materials cover the field from A to Z...from asbestos to zinc!

And...if the friction material you want isn't in stock, R/M can design and make it for you. Behind the R/M representative who calls on you are the facilities of four great plants, four research organizations, and four complete testing laboratories.

Next time you're faced with a problem in design, or supply, of friction materials...get in touch with your R/M representative, or write direct.

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION

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714 W. Olympic Blvd., Los Angeles 15, Calif.
1017 Union Commerce Bldg., Cleveland 14, Ohio

Factories: **Bridgeport, Conn., Manheim, Pa., Passaic, N. J., N. Charleston, S. C.**

RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings
Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings
Asbestos Textiles • Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls

FIRST IN FRICTION

Metal Finishing Process Information Sheets—III

GEORGE BLACK

ALUMINUM

PHOSPHORIC ACID ANODIC PROCESS. An electrochemical process for preparing the surface of aluminum alloys for subsequent electrodeposition.

SOURCE: Aluminum Company of America, Pittsburgh, Pa.

METHOD: Anodizing in phosphoric acid electrolyte.

APPLICATION: Recommended for parts having small surface areas and relatively regular contours. Generally not suitable for high purity aluminum or aluminum-magnesium alloys. Not applicable to usual die casting alloys and still experimental with respect to sand castings.

PROCEDURE:

1. Degrease
2. Rinse
3. Inhibited alkaline cleaner
4. Rinse
5. Nitric acid dip
6. Rinse
7. Anodize in phosphoric acid electrolyte. Time, temperature, voltage and other operating conditions vary with alloy being treated.
8. Rinse
9. Electroplate

CHARACTERISTICS:

1. The anodic coating is ready to be plated as no additional film preparation is required.
2. Process is very sensitive to small variations in alloy composition.
3. Aluminum racks are required and parts must be held in tension to assure positive electrical contact. Racks must be stripped before reuse.
4. The plating procedure, after the anodic coating has been formed, is similar to that for other metals. Strong alkaline baths should be avoided.
5. Nickel and copper coatings, which form excellent bases for subsequent deposits, can be applied directly.

ZINCATE. A non-electrolytic immersion process for preparing the surface of aluminum and its alloys for subsequent electrodeposition.

SOURCE: Aluminum Company of America, Pittsburgh, Pa.

METHOD: Room temperature immersion in sodium zincate solution.

APPLICATION: Suitable for all commercial alloys of aluminum. Adaptable for bulk processing.

PROCEDURE:

1. Degrease
2. Rinse
3. Alkali or inhibited alkali cleaner
4. Rinse
5. Acid
6. Rinse
7. Zinc immersion treatment for ½ to 2 min in sodium zincate solution maintained at room temperature.
8. Rinse
9. Electroplate

CHARACTERISTICS:

1. A copper strike is usually applied prior to subsequent deposition, but procedures have been worked out for direct plating of silver, brass, chromium, nickel and other metals.
2. Zincate treatment deposits an adherent zinc coating that is extremely thin.
3. The process is self-arresting, thus preventing the formation of objectionable rough deposits.
4. Unlike the phosphoric acid anodic process, Zincate does not interpose an electrically resistant layer, and is therefore suitable for applying silver coating to alumium in electrical applications.

ALUMON. A relatively simple non-electric process for preparing the surface of aluminum and its alloys for subsequent electrodeposition.

SOURCE: Enthone, Inc., New Haven, Conn.

METHOD: Simple immersion at room temperature.

APPLICATION: Suitable as a pre-plating treatment for all commercial wrought and cast alloys.

PROCEDURE:

1. Degrease
2. Rinse
3. Hot alkali cleaner
4. Rinse
5. Acid dip
6. Rinse
7. Immerse in Alumon solution at room temperature for specified time (10 sec to 2 min) depending upon alloy being treated.
8. Rinse
9. Electroplate

CHARACTERISTICS:

1. The Alumon treatment deposits a zinc-copper alloy that is firmly adherent and serves as a base for subsequent plating.
2. Treatment is adaptable for manual or automatic operation.
3. Cadmium, copper, nickel, zinc and silver can be deposited directly on Alumon surface; Chromium, gold and tin require primary coats of nickel, copper or cadmium.
4. Since the process is non-electric, throwing power is unlimited.
5. Slight changes in the precleaning procedure result in bright plating that does not require subsequent buffing.
6. Operation and control of process is extremely simple.

SAT-N-DIP. A non-electric process for imparting to wrought and extruded aluminum a smooth uniform satin finish.

SOURCE. Frederick Gumm Chemical Co., Inc., Kearny, N. J.

METHOD: Simple immersion.

APPLICATION: Applicable to all wrought and extruded aluminum alloys and some cast alloys. Not suited for Type 43, 47, 355 and 356 castings.

PROCEDURE:

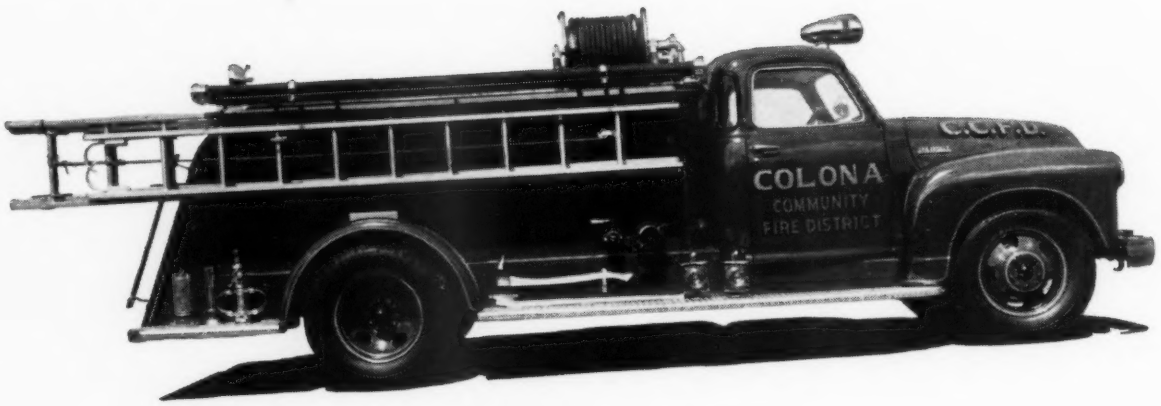
1. Immerse in alkaline etch solution maintained at 170 F for one to two min.
2. Rinse.
3. Immerse for 15 to 30 sec at room temperature in acid de-smutting solution.
4. Rinse.

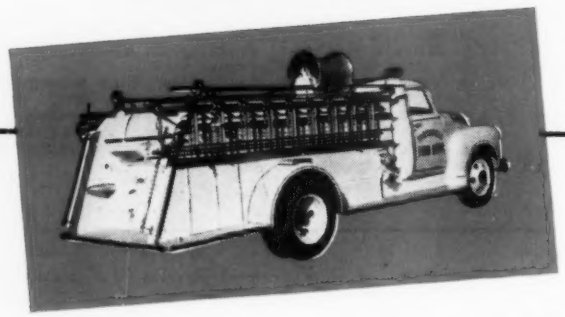
CHARACTERISTICS:

1. Sat-N-Dip process obliterates minor surface scratches, tool marks and irregularities of surface coloring.
2. Surface is uniform and has an attractive appearance.
3. Removes dirt, oil, lettering and surface oxides, and develops a passive surface with a resistance in the range of four to ten micro-ohms.
4. Heliarc welds can be made without concern for spitting or burning. Maximum tip life and uniformity of spot welds can be obtained.
5. Forms excellent base for paint primers. Baked clear-lacquer surface has excellent salt spray and humidity resistance.
6. When used as a pre-treatment before anodizing welds, a clean, uniform, white surface finish results.
7. Stainless steel tanks are required for the acid solution.

"INCREASED EFFICIENCY...DECREASED COSTS WITH N-A-X HIGH-TENSILE STEEL"

Fire Fighter Truck Company, Rock Island, Illinois





Here is what the Fire Fighter Truck Company of Rock Island, Illinois has to say about N-A-X HIGH-TENSILE steel.

"In the use of this steel, we have increased the efficiency of our fire trucks and at the same time decreased our construction costs. We are now permitted to increase the hose carrying capacity using the same gauges as we formerly did with plain hot rolled sheet steel.

"The added strength of N-A-X HIGH-TENSILE permits us to install booster tanks of larger gallonage. The corrosion-resistant properties of the steel has shown to good advantage in that longer life is noted in our booster tank.

"We have found that in applying paint to this steel we can secure a better and longer lasting bond due to its impact- and abrasion-resistant qualities. These same qualities reduce shop imperfections from abrasion and impact, thus reducing surface refinishing prior to painting."

The high physical properties of N-A-X HIGH-TENSILE steel can help *you* increase your production . . . improve your product . . . reduce your fabricating costs.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N-A-X
HIGH-TENSILE STEEL

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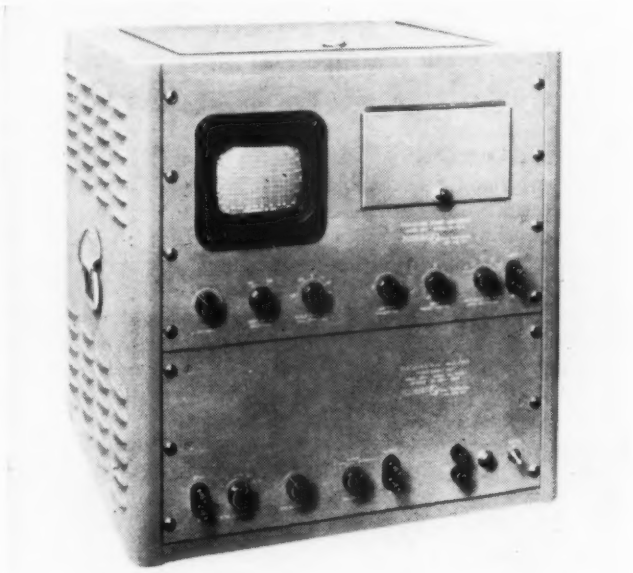
NEW MATERIALS AND PARTS

INDEX OF ITEMS

Product	Manufacturer	Page
Coating for Aluminum	American Chemical Paint Co.	172
Connector, Cable	Allied Electrical Mfg. Corp.	170
Contactors, Reversing	RBM Div., Essex Wire Corp.	164
Counter, Photo-Electronic	Potter Instrument Co., Inc.	166
Couplings, Flexible	Lord Mfg. Co.	170
Cubicles, Instrument Housing	K & H Industrial Prod., Inc.	161
Drafting Machine	Emmert Mfg. Co.	172
Filter, Unit-Type Water	Magneswitch, Inc.	168
Frequency Analyzer	Panoramic Radio Corp.	161
Generator, Signal	Servo Corp. of America	164
Grease Tester, Ball-Bearing	General Electric Co.	166
Indicator, Pressure	Automatic Temperature Control Co.	172
Indicator, Strain Rate	Baldwin Locomotive Works	168
Meter, Photoelectric Exposure	General Electric Co.	166
Motor, Single Bearing	Electro-Engineering Prod. Co., Inc.	168
Nuts, Counterbored Weld	Grip Nut Co.	170
Pumps, Gear	Eastern Industries Inc.	162
Recorder, Multi-Pen	The Foxboro Co.	168
Regulators, Air Pressure	Hannifin Corp.	170
Relay, Miniature Control	Struthers-Dunn, Inc.	164
Relay, Time Delay	DiaPHlex Div., Cook Electric Co.	170
Rivets, Flush-Head	Cherry Rivet Co.	170
Seal, Valve Stem	Hammel-Dahl Co.	162
Speed Reducers, Motorized	The Falk Corp.	161
Starters, Magnetic	Ward Leonard Electric Co.	172
Timer, Automatic Camera	Industrial Timer Corp.	162
Tube Fitting, Self-Flaring	Scovill Mfg. Co.	168
Valve, Air Flow Regulator	Industrial Designs Labs.	162
Valve, Small Solenoid	Carlton Products Co.	172
Wattmeter, Wide Range	Hickok Elec. Inst. Co.	164
Wire, Moisture Resistant	U. S. Rubber Co.	166



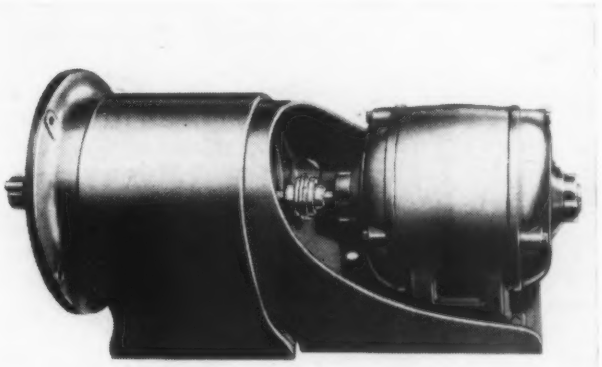
Frequency Analyzer

Sonic Panoramic Radio Corp., 92 Gold St., New York 7, N.Y.

Model AP-1 sonic analyzer is a scanning heterodyne-type instrument designed to give graphic indications of frequency distribution versus amplitude of components in complex waves. Continuous spectrum from 40-20,000 cps is scanned once per second at a logarithmic rate, and frequencies contained therein are presented as vertical pips on cathode-ray tube screen. Latter is of the long persistence variety so that indications remain on screen during entire scanning period.

With this receiver, it is possible to study one or more complex wave forms simultaneously. Observation of changes in waveforms, can be made either while waveform varies in random manner or while input values are changed. Self-contained voltage and frequency calibrators facilitate periodic checks of scale calibration.

With a constant impedance of 250,000 ohms, instrument can be adapted for various uses as the input voltage ranges from 500 microvolts to 500 v for full scale indications. Useful for determining characteristics of such equipments as public address systems, oscillators, modulators and other audio devices, unit also provides a means for analyzing effects of feedback systems as percentage of feedback is varied. Fourier analyses of square, triangular, rectangular and sawtooth waves can be made, and the instrument is applicable for comparison testing of materials for such imperfections as internal cracks, stresses and strains. Unit operates from 115/230 v, 50-60 cycle source and consumes 100 watts.



Motorized Speed Reducers

The Falk Corp., Milwaukee 8, *Wis.*

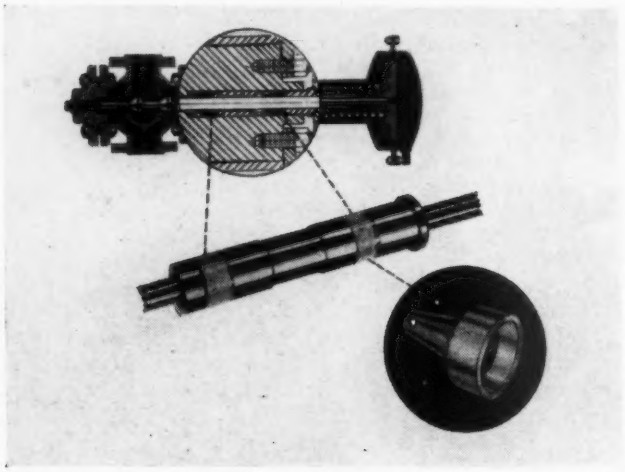
Line of speed reducers with integral motors for horizontal or vertical applications can be adapted to provide output shaft speeds from 1 to 1,430 rpm. Helical gears are heat-treated alloy steel with tapered bores for simple interchangeability. Type D flanged NEMA motors rated up to 30 hp at 1,750 rpm can be accommodated on the mounting base. Special grid-type couplings can be used as shown or motor can be close-coupled if desired. Sealed gear housing acts as oil retainer as well as dust and moisture barrier.

Instrument Housing Cubicles

K & H Industrial Prod., Inc., Dept. 19, 459 *Morgan Ave., Akron* 11, *Ohio*

Instrument housings, equipped with hinged rear doors, are available as single units (type No. 1), or in a variety of bolted combinations in which cubicles can be added,

interchanged or removed to meet varying operational conditions. Type No. 2 consists of specified number of cubicles welded together but with divided fronts to simulate individual sections. When intended for use under conditions involving gases, vapors or dust, units can be fabricated with vapor-sealed doors and gas-tight, welded seams. Cubicles are available in a variety of widths from 18 to 36 in., depths from 12 to 21 in., and heights from 72 to 96 inches.



Valve Stem Seal

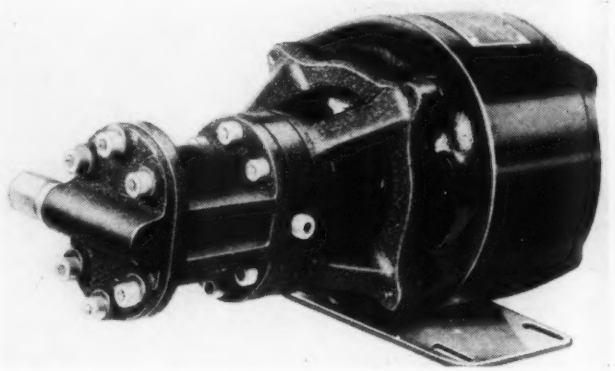
Hammel-Dahl Co., 243 Richmond St., Providence 3, R.I.

Valve stem and seal assembly replaces the conventional packing box in control valve shown in illustration. Device is claimed to be frictionless and leak-proof regardless of the static pressure on the valve body. System pressure on unsupported lower lip of seal secures valve stem. No take-up or adjustment of the inert plastic seal is necessary as it is self-lubricating and resistant to chemical attack. Stem can be positioned to an accuracy of 0.001 in. at full vacuum or at pressures up to 25,000 psi gage.

Automatic Camera Timer

Industrial Timer Corp., 115 Edison Pl., Newark 5, N. J.

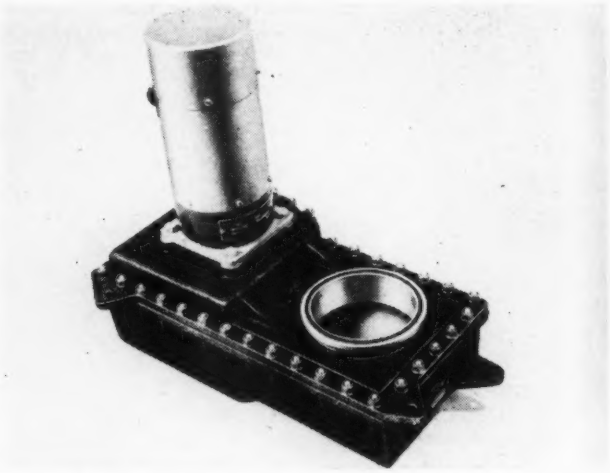
Designed for controlling the Western Electric Fastax camera, Model J-410 automatic timer synchronizes the camera to the sequence of events to be photographed, doubles the picture-taking speed of the camera and controls film speed. A built-in variable transformer controls voltage to the camera from 0 to 270 v, making the speed range of the camera infinite. Unit has a time cycle of from 5 cycles to 5 sec and will control the sequence of events to camera operation in any of eight positions.



Compact Gear Pumps

Eastern Industries, Inc. 296 Elm St., New Haven 6, Conn.

Two models of G-W Series gear pumps rated at $\frac{1}{2}$ and 1 gpm will handle non-lubricating liquids at pressures up to 200 psi. Both are built with a stainless steel drive gear and a graphite-carbon driven gear for reduction of wear. Design includes a graphite-impregnated carbon bearing that is hydraulically balanced and protected by a mechanical seal. Housings are bronze and the close-coupled motors are either $\frac{1}{6}$ or $\frac{1}{4}$ hp. Belt and flexible-coupling units are also available.



Air Flow Regulator Valve

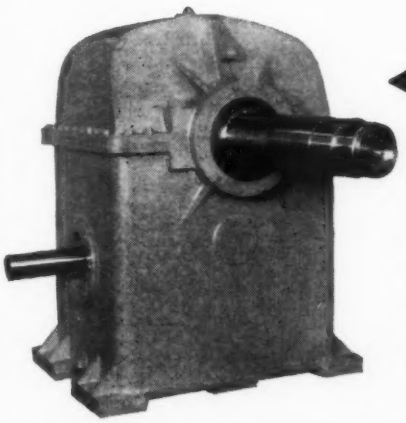
Industrial Design Laboratories, 12120 Wagner St., Culver City, Calif.

Electrically actuated air valve will operate in any high temperature, high pressure air system. It is designed specifically for use on turbo-jet aircraft to modulate air flow, and as an "on-off" valve in a cabin air conditioning system or wing empennage anti-icing system. Valve has a pressure range from 0 to 140 psi gage, and a temperature range of −65 to +500 F. The electric actuator, which conforms fully to AN-M-10a specifications, has a power

For Materials Handling Equipment too-

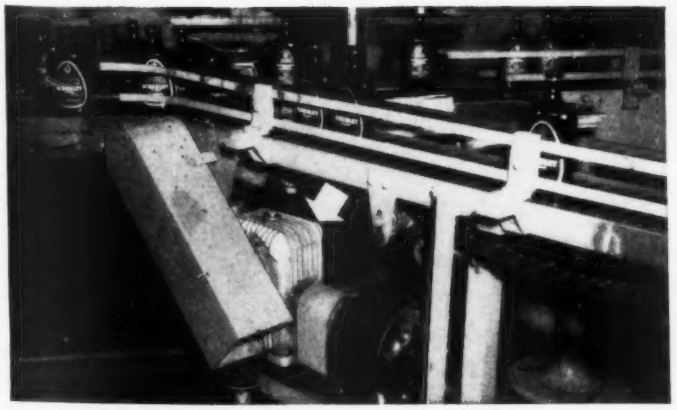
DON'T LET THE SMALL SIZE OF CONE-DRIVE GEARING FOOL YOU

Cone-Drive gears are "double enveloping." That means more contact per tooth, and more teeth in contact. Compact, light weight standard Cone-Drive reducers and gearsets will take on any other right angle reduction gearing of comparable size and give it odds. Here are a few random examples. Tell us about your gearing problems. We may be able to help you improve them and reduce costs.



500 hp (Class I Service) on 24" CENTER DISTANCE

This Cone-Drive 24" center distance speed reducer is typical of the many which have replaced conventional reducers that failed. Reason? Much greater load carrying capacity size for size. Standard reducers are available up to 18" C. D. (800 hp.) Semi-standards up to 48" C.D.



MOTORIZED CONVEYORS

These standardized pivoted conveyors for carrying away filled bottles in various Schenley plants are each driven at 80 ft. per minute by a standard Cone-Drive 3" Center Distance reducer. Compactness, freedom from trouble, and light weight are a big asset here as in many other Cone-Drive installations.

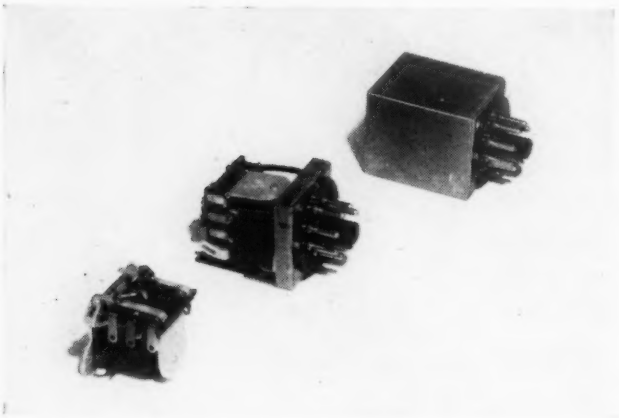
CRANES AND HOISTS

Smaller Cone-Drives handle bigger loads, stay put, increase operating speed. Wellman Engineering Co., Cleveland, O., in its new 6-ton cranes, for instance, uses a 6" Cone-Drive to move crane along rails, and a 10" Cone-Drive for rotating the boom. For equal horsepower it would have been necessary to use a 16" center distance conventional gearset for boom rotation.

CONE-DRIVE

CONE-DRIVE DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road, Detroit 12, U.S.A.

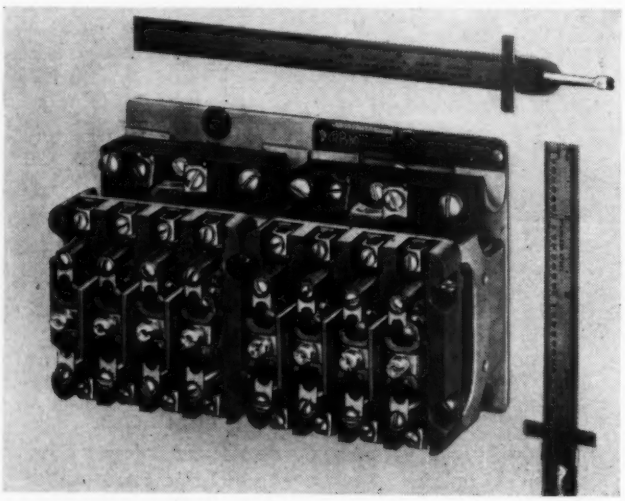
consumption of ½ to 1 amp at 24-28 v d-c. Time required for actuation from the closed to open position is 20 to 25 sec, depending upon the actuator used. Diameter of the port is 3½ in.; weight is 14¾ pounds.



Miniature Control Relay

Struthers-Dunn, Inc., 150 N. 13th St., Philadelphia 7, Pa.

Type 118XBX miniature relay can be used on a-c, d-c or on semi-rectified a-c power. Magnetic structure utilizes two working air-gaps that provide high d-c sensitivity. Hinge-pin armature suspension insures reliable operation under heavy load. Device has double-pole, double-throw contacts rated 2 amp at 115 v a-c. Normal d-c operating power is 0.15 watt with a max coil resistance of 2,200 ohms. A-c relays operate on approximately 9 v-a with coils rated up to 115 v, 60 cycles. Open type relay is 1½ in. high by 1⅛ in. long by 1 in. wide and weighs approximately 2 ounces. It can be incased in a metal inclosure 1⅜ in. square and 1¾ in. high (see illustration) and equipped with a vacuum tube type octal base.



Reversing Contactors

R-B-M Div., Essex Wire Corp., Logansport, Ind.

A series of contactors for overhead doors, hoists, torque motors, motor operated valves and other reversing motor applications is available in ratings up to 2 horsepower. Unit illustrated is rated at 10 amp open, 9 amp inclosed, for ¾ hp at 110, 208/220, 440/600 v, single or polyphase. While contactors are compact, accessibility has not been sacrificed as magnet coil and all contacts can be readily removed for inspection or replacement. Design features include continuous duty 50/60 cycle coil, E-type laminated magnet with floating type laminated armature, melamine insulation and special alloy contacts. Assemblies can also be supplied with sheet steel inclosures.

Wide Range Wattmeter

Hickok Electrical Instrument Co., 10606 Dupont Ave., Cleveland 8, Ohio

Model 900B v-a wattmeter is designed for testing all types of a-c appliances from clocks to 200 v electric ranges. A special current transformer is built in to cover the ranges of 5,000 and 10,000 watts, and 65 and 130 amp. Continuity tester consisting of a neon lamp connected between line and load binding posts provides a simple, accurate test for short circuits. Scale ranges are: watts—0 to 100, 500, 1,000, 2,000, 5,000, 10,000; amperes—0 to 1.3, 6.5, 13, 26, 65, 130; volts—0 to 130, 260; milliamperes—0 to 260. Meter scale is 3¾ in. long.

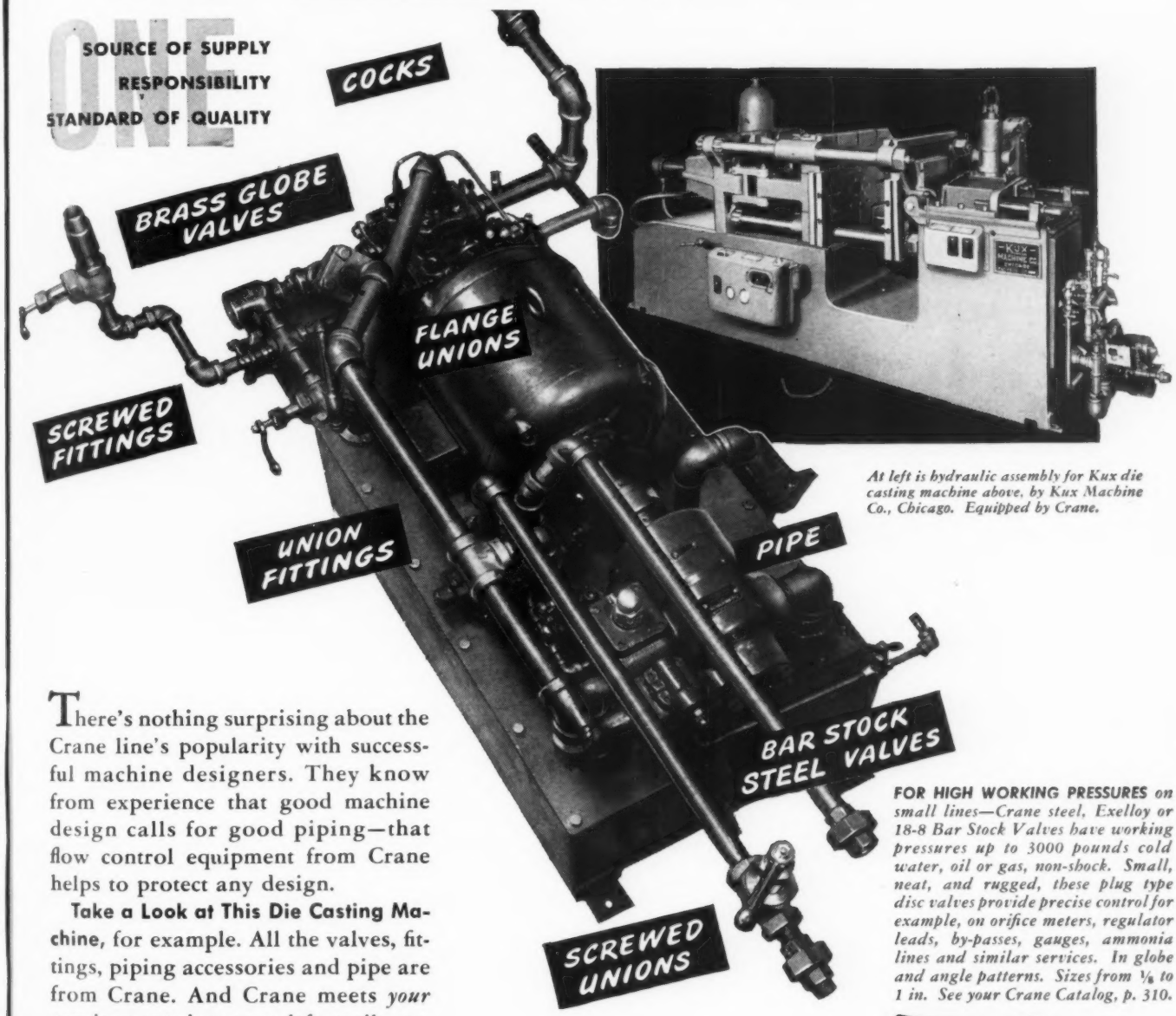
Signal Generator

Servo Corporation of America, New Hyde Park, N.Y.

Electronic signal generator can be used in conjunction with a cathode ray oscillograph to make precise checks

"Designers' Choice" in piping equipment ... the complete CRANE line

ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY



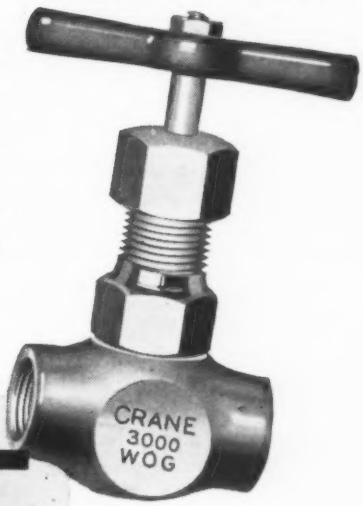
At left is hydraulic assembly for Kux die casting machine above, by Kux Machine Co., Chicago. Equipped by Crane.

There's nothing surprising about the Crane line's popularity with successful machine designers. They know from experience that good machine design calls for good piping—that flow control equipment from Crane helps to protect any design.

Take a Look at This Die Casting Machine, for example. All the valves, fittings, piping accessories and pipe are from Crane. And Crane meets *your* requirements just as satisfactorily, regardless of the design on your boards—offers you the world's widest choice of piping equipment ... in brass, iron, steel, and corrosion-resistant alloys.

Relying on Crane as the **Sole Source** for everything in piping simplifies buying and storekeeping, as it does specifying. You don't have to shop around. **One Responsibility** for quality of equipment helps to speed product assembly operations in your plant. And to your customers a Crane-equipped product has added value. For the **High Quality** of Crane equipment stands unsurpassed for more than 90 years.

FOR HIGH WORKING PRESSURES *on small lines—Crane steel, Exelloy or 18-8 Bar Stock Valves have working pressures up to 3000 pounds cold water, oil or gas, non-shock. Small, neat, and rugged, these plug type disc valves provide precise control for example, on orifice meters, regulator leads, by-passes, gauges, ammonia lines and similar services. In globe and angle patterns. Sizes from ⅛ to 1 in. See your Crane Catalog, p. 310.*



Crane Co., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

EVERYTHING FROM ...

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

of servo loop components including motors, synchros, gyros, amplifiers and accelerometers. Frequency response can be plotted and transient characteristics deduced. A carrier signal having a frequency ranging from 50 to 800 cps at 115 v can be impressed on the mechanism under test and measurements made of frequency versus amplitude attenuation and phase shift. Amplitude range is from 2 millivolts to 100 v rms; phase lead or lag accuracy is within 2 deg. Operation is on 115 v, 60 cycle current; power consumption is 40 watts.

Moisture Resistant Wire

United States Rubber Co., Rockefeller Center, New York, N. Y.

Laytex RUW electrical wire with natural latex rubber insulation is designed for use in wet locations where high moisture resistance gives it longer life and increased safety. It is suitable for underground lead-ins and also for police and fire alarm cables. Tests conducted by Underwriters' Laboratories, during which the wire was immersed in water at a temperature of 122 F for twenty-four weeks, showed an insulation resistance curve that rose from 500 to 2,400 megohms per 1,000 ft of wire. A normal insulation resistance curve shows a sharp drop after two to four weeks immersion. Tensile strength and elongation properties are also improved by the rubber insulation.

Grease Tester

General Electric Co., Schenectady 5, N. Y.

Ball-bearing grease tester simulates conditions that contribute to the deterioration of a grease, thereby permitting motor and grease manufacturers to compare the performance of one grease with another. Equipment consists of the tester and a control box (not shown). Tester is a small motor-driven assembly with two bearings. A 500 w heater, located between these bearings, simulates the source and flow-paths of heat in an electric motor. Temperature of the outer bearing race is measured by a pair of copper-copnic thermocouples. Control box consists of two thermostats and a panel on which are mounted a motor switch, a line switch, an actuation button and a time meter. Meter, marked in tenths of hours, measures time on a cyclometer-type counter up to a period of one year. When the test bearing overheats so that the first thermostat is unable to control the temperature, the second thermostat shuts off the heater and drive motor.

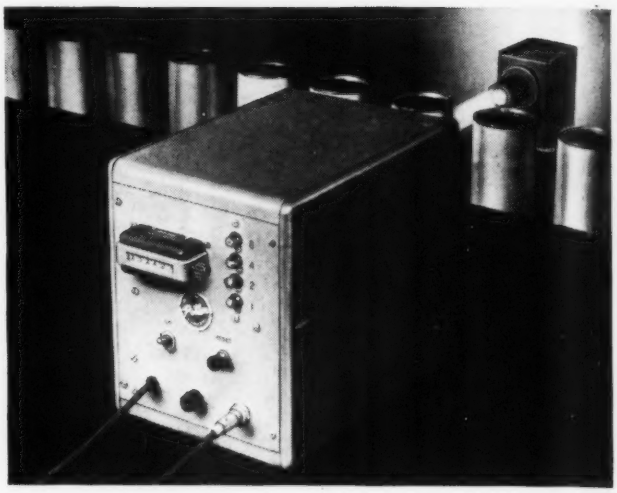
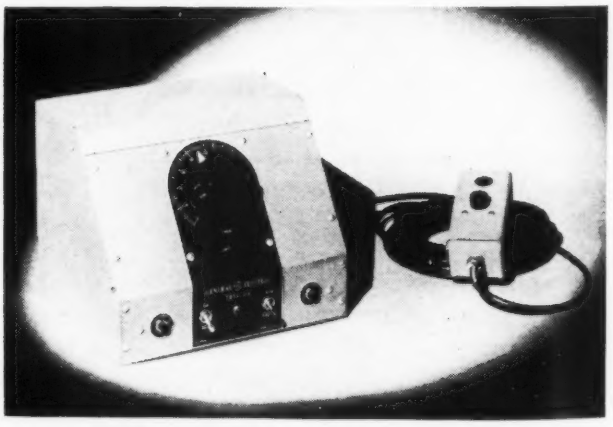


Photo-Electronic Counter

Potter Instrument Co., Inc., 136-56 Roosevelt Ave., Flushing, N. Y.

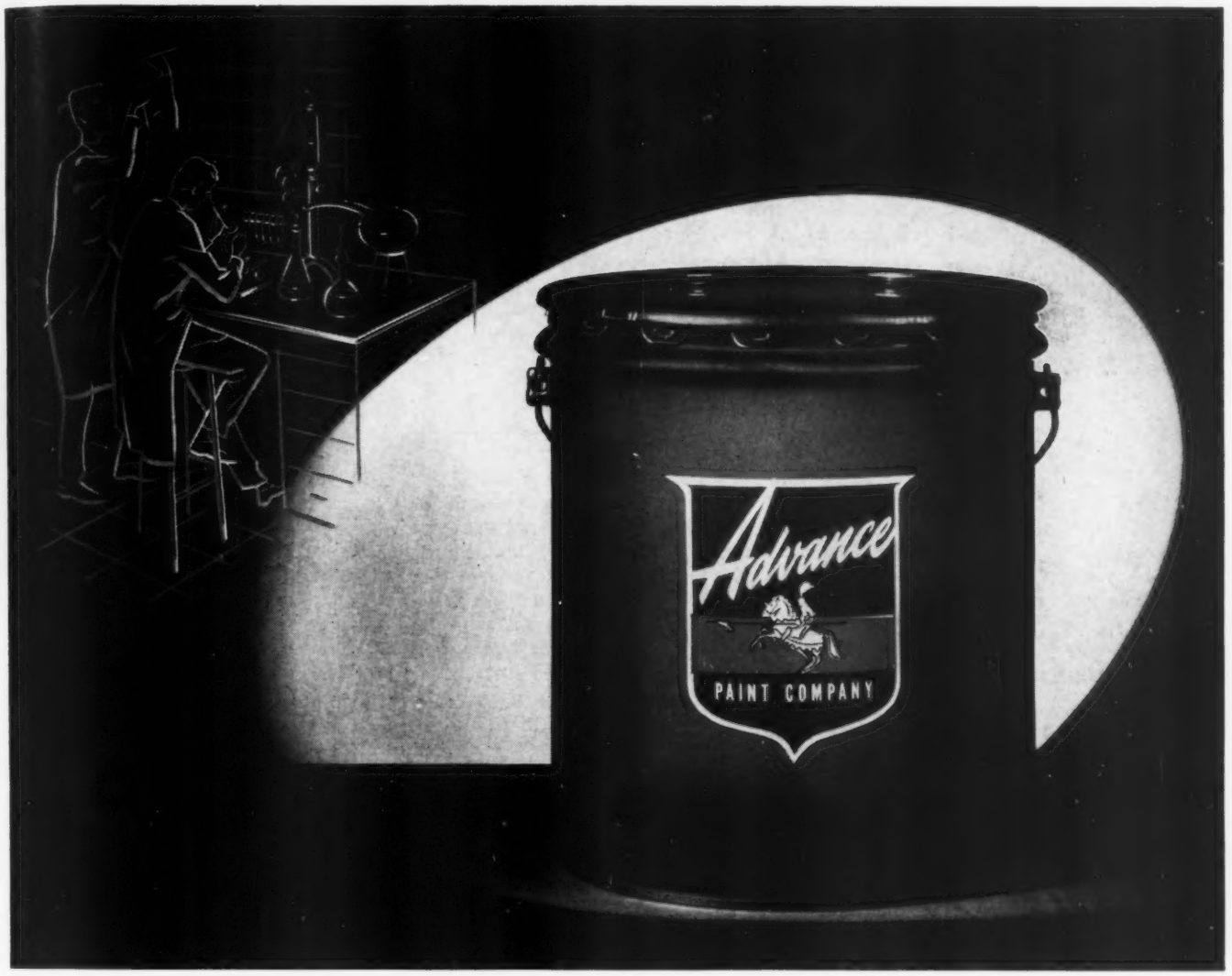
Model 310 photo-electronic counter can be used for counting impulses up to 6,000 units per minute. Instrument includes photo-electric cell, electric decade and six digit register. Light source in a separate housing provides mounting flexibility. With the counter decade ahead of electro-mechanical register, counting speed is scaled down by a factor of ten. Last digit is recorded on neon lamps of counter decade and remaining numbers are indicated on the mechanical register, providing maximum registration of seven digits. Small objects as well as closely spaced parts can be counted since photo-electric beam is $\frac{1}{4}$ in. wide and responds to light changes of 25 percent.



Photoelectric Exposure Meter

General Electric Co., Schenectady 5, N. Y.

Improved model of automatic exposure meter is applicable where photographic exposures, requiring time intervals of 3 sec to 60 min must be held to close limits. Instrument is made up of two units, exposure integrator and totalizer. Latter can be placed either inside or outside of darkroom. Dial can be reset in total darkness and exposure can be stopped at any time for adjustment. Operating on the principle that exposure of a photographic material is proportional to the product of light intensity and exposure time, meter integrates these variables and ends an exposure after the predetermined foot-candle-



5 GALLONS OF LACQUER

50 YEARS OF EXPERIENCE

Here's a drum of Advance Lacquer. It contains fifty years of experience . . . and five gallons of a fine finish.

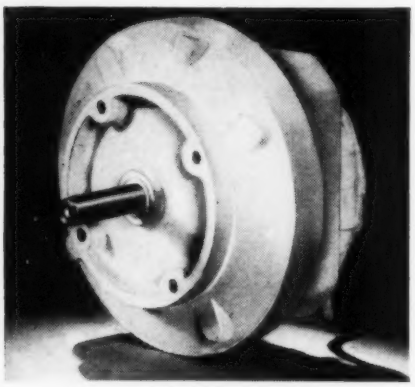
Service technicians of the Advance Paint Company have developed formulations to solve thousands of individual finishing problems. As a result, characteristics have been built into Advance finishes that make them easy to apply and quick to dry, speeding up your finishing operations. All the metal finishes manufactured by the Advance Paint Company are made to satisfy the most exacting requirements . . . are adapted to low-cost finishing operations.

This experience can go to work for you. An Advance field representative will come into your plant to help you solve *your* finishing problems.

Manufacturers of Industrial Finishes

Advance PAINT COMPANY
INDIANAPOLIS, INDIANA

seconds set on the face dial have elapsed. Sensitivity range is from 50 to 400 ft-candles within a linear precision of 1 percent. Meter consumes 45 w on a 115 v, 50/60 cycle circuit.



Single-Bearing Motor

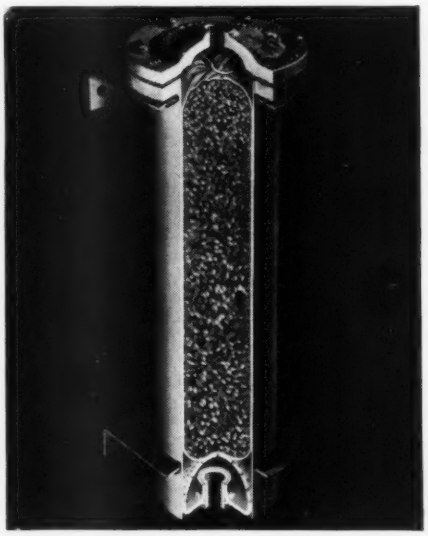
Electro-Engineering Products Co., Inc., 4824 W. Kinzie St., Chicago 44, Ill.

Utilizing a single bearing to obtain accurate line-up in air gap, the motor is of 4-pole type with no-load speed of 1,700 rpm and full-load speed of 1,550 rpm. Single bearing consists of two phosphor bronze sleeve bearings with space below for felt-packed oil reservoir. In addition to open type, models can also be supplied with completely enclosing cover, or with cover having a back opening for use with internal cooling fan. Three models are available with continuous duty ratings of 1/100, 1/80 and 1/60 hp. Larger ratings can be furnished for intermittent service.

Multi-Pen Recorder

The Foxboro Co., Foxboro, Mass.

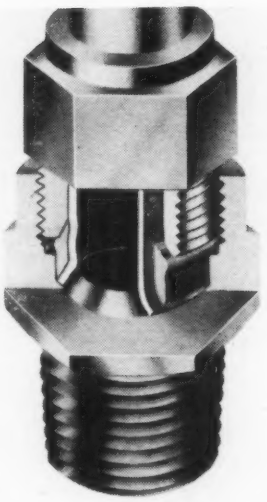
Multi-Record Dynalog electronic recorder makes from one to six different records on one circular chart. Traces are actually colored dots closely spaced. Recorder has one measuring system, either resistance bulb or EMF type. A positive-acting switching assembly automatically brings the vari-colored pens into recording position at six-second intervals, in any sequence desired. Sequence and number of points can be simply changed. Complete color-coding prevents possible mis-mating of circuits and pens. Rotacolor pen wheel holds the six pens that are magnetically selected in turn and held in recording position by a single pen arm. Instrument can be used for measurement of temperature, pressure, humidity, liquid level, pH, conductivity, speed and other process variables. A special "dry ink" insures clean recording and the instrument will operate continuously for several weeks without need for re-inking.



Unit-Type Water Filter

Magneswitch, Inc., 4259 S. Western Ave., Chicago 9, Ill.

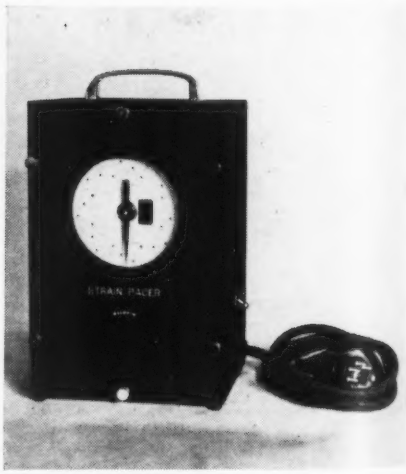
Self-contained water filter of renewable cartridge type meets the need for effective water conditioning at point of use on beverage fountains, individual water fountains and domestic water taps. Filter also has application on drink carbonators and syrup mixing units where the taste of chlorine or unpalatable impurities is objectionable. Basic model of the filter consists of a specially prepared mineral cartridge measuring approximately 3 in. dia by 13 in. long and housed in a cylinder of similar dimensions. A bolted end cap is provided for access to the filter cartridge and ¼ in. pipe thread connections are located at top and bottom.



Self-Flaring Tube Fitting

Scovill Manufacturing Co., Waterbury 91, Conn.

Uniflare self-lubricating tube fitting can be disassembled and reconnected repeatedly without weakening the seal or damaging the flare. During installation, thrust collar in the nut shears off and fitting clamps onto the tube to form a sealed joint. Flare has 37 deg taper. Inverted joint provides sealing surfaces and intimate tube support that minimize vibration fatigue. Fittings are made in a range of shapes for use with copper, aluminum, Monel and annealed steel tubing.



Strain-Rate Indicator

Baldwin Locomotive Works, Philadelphia 42, Pa.

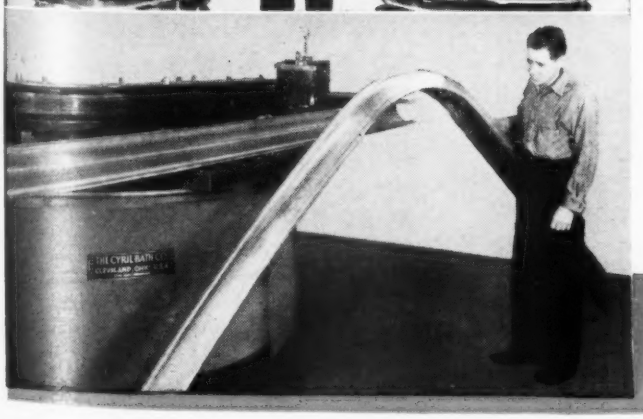
Instrument gives direct indication of rate of displacement between test specimen-gage points and rate of motion of a testing machine crosshead. Transmitter is mounted in Baldwin autographic recorder where it is controlled

Give your draftsmen the GREEN LIGHT!

There's a NEW Freedom of Design with BATH CONTOUR FORMING

Forming frieze molding from aluminum extrusion. Note that only one die is used, instead of customary two.

Showing aluminum sash frame formed for motor buses.



Main body frame for parcel truck formed in one piece from large aluminum extrusion.

Pitch that high-die-cost barricade to one side and give the go signal to your draftsmen and engineers to proceed with those improved designs involving curved metal parts. For BATH can form to blueprint at surprisingly low die and forming costs.

High-alloy materials are cold-formed into a wide variety of shapes with precision accuracy, without wrinkling or buckling, by means of BATH forming methods. Bends of varying radii and compound and reverse curves present no difficulties.

BATH Contract Forming offers a new freedom of design by removing the red stop light of high die cost. Write for booklet or send your blueprints and engineering details.

Free Booklet

12 page booklet—with photos of production work and detailed information on wide range of cost-cutting possibilities in BATH Contour Forming—yours for the asking.

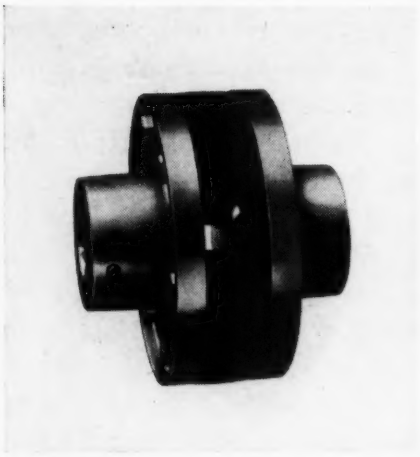
The
CYRIL BATH COMPANY
6587 Machinery Avenue Cleveland 3, Ohio

by extensometer on test specimen. Indicator shown, connected to recorder by a cable, contains a dotted disk rotated by a synchronous motor at predetermined speeds, and a coaxial pointer moved in proportion to strain of test piece. Strain-rate can be set and maintained by adjusting test machine load-rate valves until pointer speed coincides with predetermined disk speed. Pacing speeds are combined function of strain-follower magnification and speed of rotation of dotted disk.

Flush-Head Rivets

Cherry Rivet Co., 231 *Winston St., Los Angeles* 13, *Calif.*

Types CR 158 and CR 159 two-piece self-plugging rivets made of 17ST aluminum alloy have a shear strength comparable with that of solid rivets made from the same material. When used in thin sheeting where greater strength is required, shanks fabricated from 24ST aluminum are recommended. The 17ST stem fractures flush with the head permitting rapid installation and application to assemblies where high tensile loads are not of primary importance.



Flexible Couplings

Lord Mfg. Co., Erie, Pa.

Line of couplings available in sizes from 1/50 to 100 hp at 1750 rpm. Couplings in the range between 1/50 to 15 hp allow 15 deg deflection under rated loads. Sizes 30 to 100 hp permit 3 deg deflection, and all couplings will accommodate at least 2 deg angular and 1/32 in. parallel misalignment. In the small sizes the neoprene flexing elements are of one piece, but in the larger models they are made up of several cylinders operating in shear and bonded to steel plates.

Time Delay Relay

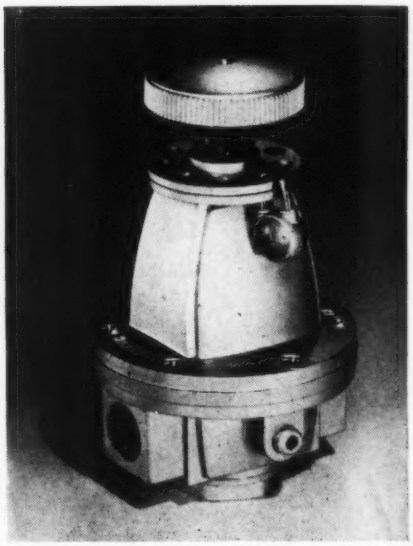
DiaPHlex Div., Cook Electric Co., Chicago, Ill.

Tarrytron time delay relay can be adjusted for intervals varying from one second to two minutes within tolerances from three to ten percent. Contacts can be arranged in Types A, B or C. Hermetically sealed case with octal base is 2 1/16 in. long and 1¼ in. in diameter; complete unit weighs 3 oz. Heater elements are adaptable to voltages from 6 to 115 v, a-c or d-c. For continuous duty, a separate miniature relay that is cut out of the circuit after performing its delay functions is utilized. Load current is then transferred to snap-acting contacts.

Cable Connector

Allied Electrical Mfg., Corp., 1 *N. La Salle St., Chicago, Ill.*

The Paige No. 52 connector provides a positive anchor for non-metallic sheathed cable in electrical outlet boxes. Fitting is made of spring steel and plated to prevent corrosion. It is installed by pressing firmly from the inside of box into knock-out. Cable is pushed through the desired length from outside and locked by the spring jaw. Should removal be necessary, the connector is pressed together with pliers and pushed through knock-out. Underwriters' Laboratory approval has been obtained.



Air Pressure Regulators

Hannifin Corp., 1101 *S. Kilbourn Ave., Chicago 24, Ill.*

Series PRD and LRD air pressure regulators with free-floating valve stems are designed for applications on compressed air supply lines. Series PRD regulators are equipped with a flange for panel mounting where the adjusting knob extends through to the front of an instrument board, while the valve itself is back of the board for convenience in making pipe connections. Series LRD units (illustrated) are for installations where it is desirable to lock the adjusting knob against unauthorized change of pressure setting. Locking is accomplished with any common type of padlock by passing the hasp through matching holes in two parallel disks. The disk arrangement provides 36 possible locking combinations and fine pressure adjustment. Both are available in ⅜ and ½ in. sizes for primary pressures to 150 psi and for secondary pressures of from 5 to 125 pounds per square inch.

Counterbored Weld Nuts

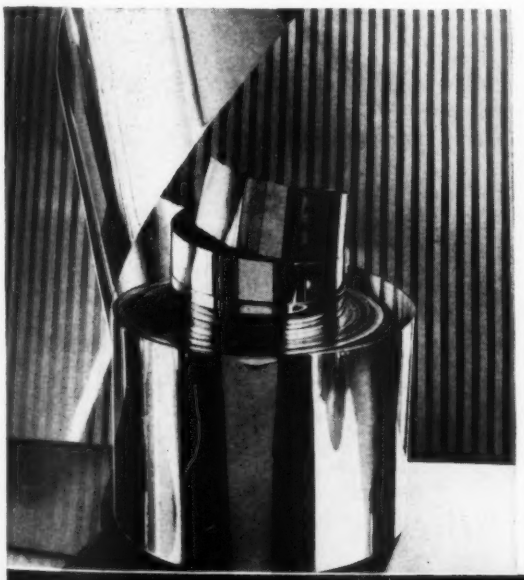
Grip Nut Co., 308-*J S. Michigan Ave., Chicago* 4, *Ill.*

Weld nuts, used where lack of space makes nut insertion difficult or where

"Sampler" Portfolio Offered by Plated Metal Manufacturer

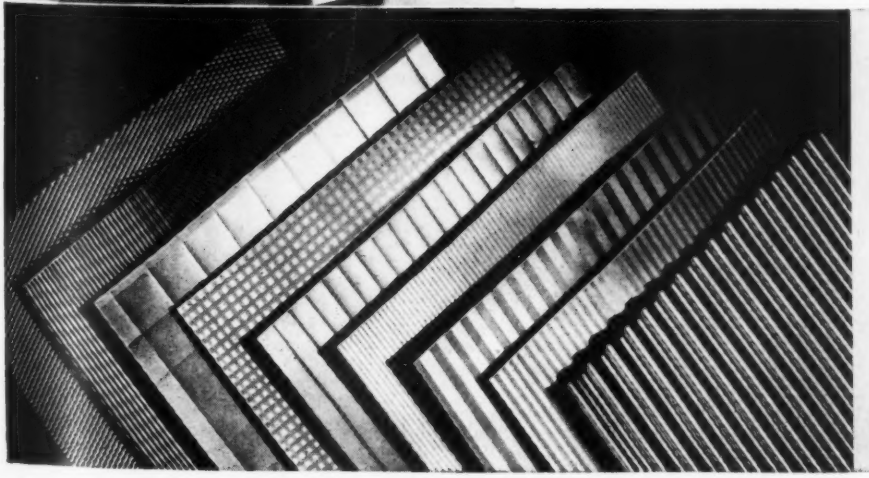
NOTHING speaks as loudly in praise of a product as a sample of the product itself, and this is certainly true of the gleaming, highly polished metals in various finishes and patterns that comprise the Nickeloid Metals line. The manufacturer of these metals, American Nickeloid Company, has just prepared a new portfolio showing representative samples of the metals themselves. They call it "The Sampler." These metals, available in sheets or in coils, comprise finishes of chromium, nickel, copper or brass, pre-plated to such common base metals as copper, brass, steel, zinc, or aluminum.

Designers, manufacturers, production men may have a copy of "The Sampler" free by writing on their company stationery and asking for Booklet No. 4.



Many people think that plated parts are always stamped and then individually plated. Hundreds of Manufacturers use Nickeloid pre-plated Metals in sheets or coils — stamp or form the parts — then assemble, without further polishing, plating or finishing. There is a basic economy in the use of Nickeloid pre-plated Metals which we would be glad to explain further.

Not only are Nickeloid Metals sampled in bright and satin finish plain metal, but in interesting crimps and stripes. Industry has found wide use for these pre-finished metals.

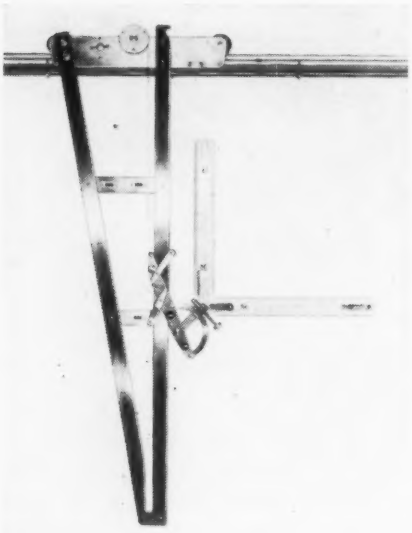


AMERICAN NICKELOID COMPANY

Established 1898

PERU, ILLINOIS

metal sections are too thin to thread, are designed with a counterbored hole about one quarter of way up through underside of nut. Hole and annular space act as relief reservoirs to prevent molten welding metal from dropping into the nut threads. Thickness of nut is increased to compensate for threads removed by counterboring.



Drafting Machine

Emmert Manufacturing Co. Waynesboro, Pa.

Stainless steel drafting machine will operate on any size or make drawing board without the addition of extra equipment or alteration of the drawing board. Indexing of angles is made simple through the use of a micromatic quadrant that allows indexing of every 3 deg by "flipping" the quadrant minute adjusting screw into desired degree setting. Adjustments as fine as 2½ min of arc can be made by turning the minute adjusting screw. Both left and right-handed machines are available with vertical-horizontal counterbalancing.

Coating for Aluminum

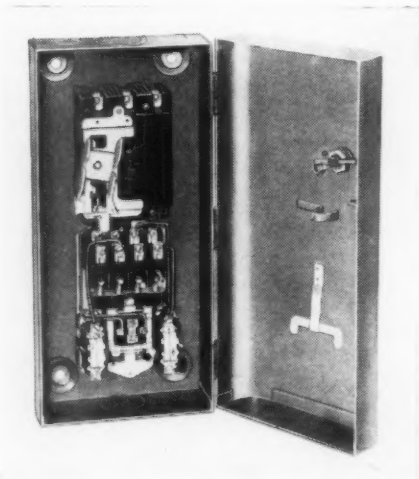
American Chemical Paint Co., Ambler, Pa.

Alodine for protecting aluminum surfaces, can be used as a base for subsequent painting or as a final finish. Coatings range in color from iridescent blue-green to greenish-yellow. Suitable for all aluminum alloys, Alodizing is a non-electric process. If parts are dipped, drying time is 2 min; if sprayed, 20 sec; and if painted, 1 to 5 minutes. Oven-drying at 280 to 350 F is recommended for best results.

Small Solenoid Valve

Caltron Prod. Co., 2221 Warwick Ave., Santa Monica, Calif.

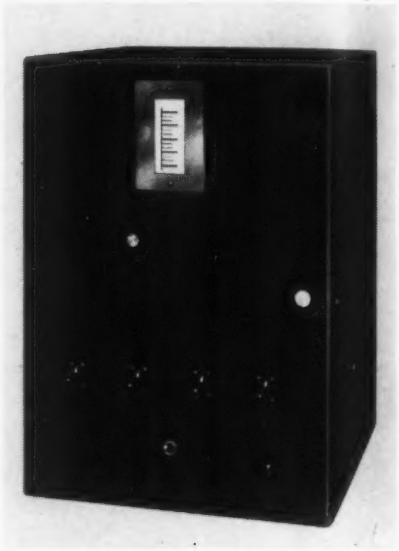
Small solenoid shut-off valve has simplified valve seat arrangement. Body material can be aluminum, brass or stainless steel making valve applicable in systems circulating either corrosive and noncorrosive fluids. Of normally open type, valve will handle pressures up to 600 psi. Sealed electrical mechanism will operate at a-c voltages ranging from 32 to 440 v or at d-c potentials from 6 to 115 volts.



Magnetic Starters

Ward Leonard Electric Co., Mount Vernon, N.Y.

Starters fulfill NEC requirements for motor branch circuit overcurrent protection, disconnect means, motor-running overcurrent device and motor controller. Each assembly consists of a magnetically operated contactor and thermal inverse time-delay overload relays combined with a thermal type circuit breaker, all housed in a NEMA Type 1 enclosure. Externally operated from the front, all circuit breakers have provision for padlocking in the "off" position, and are interlocked mechanically to prevent opening enclosure door when breaker is "on". Starters can be supplied with reset button in the cover and with local control "start-stop" pushbuttons or "hand-off-auto" selector switches. Available in five sizes to 200 hp, 3 phase, 550 v, 60 cycles maximum.



Pressure Indicator

Automatic Temperature Control Co., Inc. 5212 Pulaski Ave., Philadelphia 44, Pa.

Pressure indicator will accommodate one or a group of pressure pick-ups. Three bands controlled by the switches on the case can be calibrated either linearly or in terms of square root valves. Each scale is 72 in. long and moves full range in less than two sec. Accuracy is within 0.25 percent. Zero adjustment is made with screw on case front and, as instrument is of null-balance type, zero checking is simplified. Up to 40 selector switches can be mounted on case front. Because voltage output is produced on pressure measuring cells, several measurements can be added, subtracted or divided.

Our Mistake

The write-up of the sanitary pumps manufactured by the Waterous Co., page 172 of the September PRODUCT ENGINEERING should be corrected to read "rotary" instead of "centrifugal" pump, and "standard thread sizes from ¾ to 2½ in." instead of "2⅓ inches."

You can't keep it tight without a spring

BEFORE VIBRATION
It's tight because it was wrenched Tight
AFTER VIBRATION
It's still tight because a Kantlink expanded and held it Tight

You can wrench a nut down tight on its bolt. You can drive a spike right through the nut and bolt, or you can weld it so it can't budge—but the other parts of your bolted assembly will wear loose unless you use a spring washer which expands as inevitable wear occurs.

So with or without a nut locking device always specify Kantlink spring washers on every bolted construction.

Expanding spring power retards initial wear, then compensates for later wear, holding all parts tight longer.

A strong spring does it—nothing else can.

Write for descriptive folder today.

Originators of KANTLINK the long-range spring washer

THE NATIONAL LOCK WASHER COMPANY

Newark 5, New Jersey — Milwaukee 2, Wisconsin

"FREEZING" is expensive

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

Unique design and spring suspension prevent it in this Ward Leonard Relay

The generous wipe imparted to the contacts of Ward Leonard Heavy Duty (105) Relay by its unique design and spring suspension, results in freedom from contact "freezing" or welding.

This mighty midget will perform motor starting functions ordinarily assigned to larger relays.

Ward Leonard relays are "Result-Engineered". By modifying a basic design, Ward Leonard can give you the results of a special . . . for the price of a standard.

WARD LEONARD ELECTRIC COMPANY

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

NEW BOOKS

Modern Plastics Encyclopedia

PUBLISHED BY THE PLASTICS CATALOGUE CORP., 122 *E. 42nd St., New York* 17, *N. Y. Twelfth edition, one volume,* 1673 *pages and* 12 *charts.* $8.50.

The 1948 Modern Plastics Encyclopedia is an up-to-date revision of an authoritative collection of general plastics information. The volume is divided into the following general classifications: Plastics in products; materials; coatings; film and sheeting; synthetic fibers and fabrics; laminates and resin-wood products; technical data; engineering design; molding, extruding and casting; fabricating, finishing and assembly; machinery and equipment; stock molds; and appendix and directory. The excellent charts give valuable information on the following subjects: Plastics identification; plastics properties; chemical formulas; plasticizers; solvents; coatings; fibers properties; synthetic rubbers properties; low pressure laminating resins; laminates properties and plastic films.

The largest addition to the new edition is the section on stock molded parts, cast shapes and extrusions. In eighteen main categories, this 150-page section illustrates more than 2,000 stock mold items, listing materials and colors in which they are available, their dimensions and weights, and the names and addresses of their manufacturers. This section should prove of value to design engineers who wish to make use of standard shapes in plastics. Among the charts, two are new additions: Properties of laminates and plastic films.

How to Keep Invention Records

H. A. TOULMIN, JR., *patent attorney, Toulmin & Toulmin. Second edition, 78 pages, 5½ x 8 in. Published by Research Press Inc, Dayton, Ohio.* $2.50.

One of the most important causes of infringement or other patent difficulties in which the layman finds himself is the failure to keep adequate invention records. In answer to this problem, H. A. Toulmin, Jr., prominent patent attorney of Dayton, Ohio, has prepared this short text on how to protect patent property. Methods of record which are discussed include: Date of conception, date of disclosure to others, reduction to practice by test and experiment, proof of ordering materials for the first run production. All of these are illustrated with basic

charts and simplified record forms.

Additional patent questions answered in this volume include: What is the difference between a patent, design patent, and trademark? When are photographs to be used? What records are necessary to prove the date of conception? Also discussed is patent law pertaining to invention records, based on the latest decisions made by the Supreme Court.

Techniques in Experimental Electronics

E. H. BACHMAN, *Associate Professor of Physics, Syracuse University.* 252 *pages,* 5½ x 8¼ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $3.50.

Written with the American Standards Association definition in mind—"Electronics is that branch of science and technology which relates to the conduction of electricity through gases or in vacua"—this book shows laboratory equipment necessary to experiments in electronics. Apparatus is clearly described and related equipment is compared for specific uses. Electronic experiments are not included.

Chapters discuss vacuum systems, gages, controls, pumps and joints; glass handling techniques for production of experimental apparatus; sources of and control for charged particles; assembly and processing of electronic equipment, and miscellaneous hints and laboratory techniques. History and mathematical theory have been kept to a minimum but sources of special industrial materials and equipment are noted. Many chapters include references to more detailed auxiliary reading.

The book is written for investigators with good background of electronic principles but who need additional information on types and uses of laboratory equipment. The volume has many charts, tables and illustrations to amplify the text.

The Modern Metallurgy of Alloys

R. H. HARRINGTON, *Research Laboratory, General Electric Company.* 209 *pages,* 5⅞ x 8⅝ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $3.50.

A highly original arrangement of the subject by a practical metallurgist, this book also attempts to establish an accurate terminology for this field. Confusing definitions are eliminated so that "anneal" means but one heat-treatment, not five or six.

Heat-treatment is first defined for

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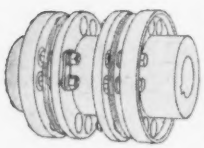

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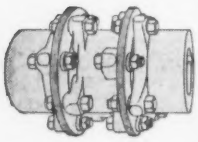

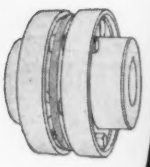

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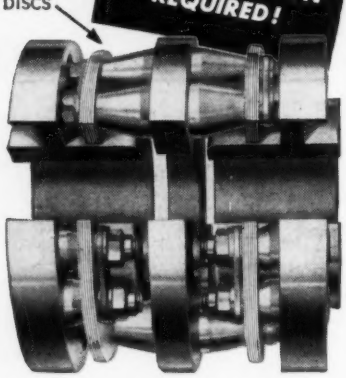

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the allotropic modifications, cold-worked solid solutions, and precipitation-hardening alloys. In Chapter 2, equilibrium diagrams are used to show the classification of alloys and their relationship to cooling curves and physical properties. The role of strain in solid state reactions is covered in Chapter 3. Other chapters include discussions on a metallurgist's periodic table, the physics of metals and their alloys, chemistry of metals, alloying factors that determine types of binary equilibrium diagrams, shrinkage, porosity, active and inactive particles.

Planning the Product

DUDLEY M. PHELPS, *Professor of Marketing, University of Michigan.* 306 *pages,* 6¼ x 9¼ *in. Published by Richard D. Irwin, Inc.,* 3201 *S. Michigan Ave., Chicago* 16, *Ill.* $4.50.

Product planning, as described by Professor Phelps, means the determination of consumers needs and desires, and the creation of products to fill those requirements. The engineering reader will find the problem of creating the product has been barely touched upon. As a study on marketing, the book proceeds from product development to the constitution of a line of products. The next chapter, "Product and Market Testing" is regrettably weak. Practical techniques for testing are not given in any detail. The exhaustive efforts of General Motors to determine consumer preferences are barely mentioned, let alone analyzed. The author mentions Good Housekeeping as maintaining laboratories for product testing! But the rigorous service testing and outstanding product development programs of such firms as Sears, Roebuck are ignored.

"Brands and Tradenames," packaging, labeling and warranty policies are covered in the final chapters. Numerous references are given, mostly from the literature of marketing studies, rather than from product development literature.

Supercharging the Internal Combustion Engine

E. T. VINCENT, *Professor of Mechanical Engineering, University of Michigan.* 315 *pages,* 6¼ x 9¼ *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $5.

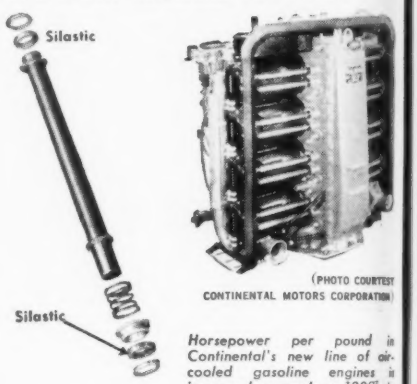
This book contains essential fundamental theory of the various forms of superchargers and turbo superchargers in use today. Also discussed are the effects of superchargers on engine cycles, power outputs and thermal efficiencies.

A very complete discussion of ther-

Silicone News
DC SILICONES

More Power Per Pound†

Call it plain laziness or call it "divine discontent", some potent force has driven us to seek more concentrated motive power ever since man started to move on wheels. But each increase in horsepower per pound has increased operating temperatures and created a need for more heat resistant materials. Dow Corning Silicones help to supply that need in such major developments as the new air-cooled gasoline engine by Continental Motors Corporation of Detroit.



(PHOTO COURTESY CONTINENTAL MOTORS CORPORATION)

Horsepower per pound in Continental's new line of air-cooled gasoline engines is increased as much as 100% in engines below 250 hp . . . more than 300% (down from 2400 to 777 lbs.) in the horizontally opposed 8 cylinder 250 hp engine shown above. In this type of engine, Silastic gaskets are essential parts of the standard push-rod and tube assembly.*

Among the many problems solved by Continental engineers in designing this compact power plant, was the leakage of oil around the push-rod tube assembly. Hot oil and operating temperatures up to 500° F. severely limited the life of conventional gasketing materials. Continental engineers, however, knew about Silastic, the rubber-like Silicone by Dow Corning, and they asked for samples and technical assistance.

Silastic solved this problem because it is more heat-stable and more resistant to hot oils and to permanent deformation at temperatures above 200° F. than any other resilient material. Use of engines in sub-zero weather is not restricted by these gaskets of Silastic 161 because they are serviceable from —90° to 500° F. For more information about Silastic, ask for data sheet No. F-5H.

†See Silicone News, Dec. 1947, for story on 50% reduction in size and weight of electric motors made possible by Dow Corning Silicone Insulation.

*TRADE MARK REGISTERED U. S. PAT. OFF.

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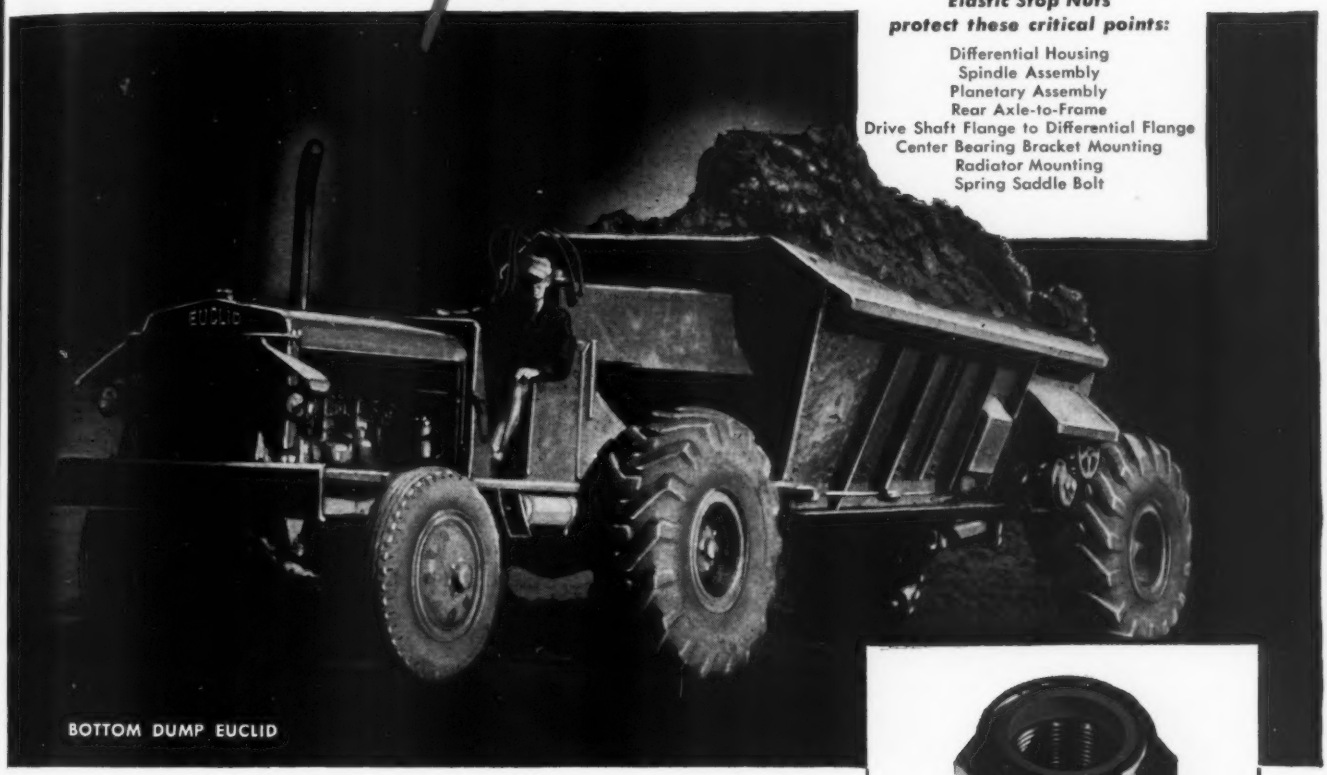
FASTENER PROTECTION *Built for Punishment* ON OFF-THE-HIGHWAY HAULS

Elastic Stop Nuts protect these critical points:

Differential Housing
Spindle Assembly
Planetary Assembly
Rear Axle-to-Frame
Drive Shaft Flange to Differential Flange
Center Bearing Bracket Mounting
Radiator Mounting
Spring Saddle Bolt



BOTTOM DUMP EUCLID

—*the Red Elastic Collar absorbs heavy-duty loading and carting* SHOCK! IMPACT!

The jarring thuds of earth, ore, sand, gravel when loading . . . the constant shock and vibration of a 20-ton load over rough off-the-highway hauls are just two of the regular occupational hazards encountered in the daily life of a Bottom Dump Euclid.

Obviously, this constant impact calls for bolted connections that will prevent costly, time consuming operational failures. Elastic Stop Nuts were the logical choice. The self-locking, self-sealing Red Elastic Collar of these reusable nuts retains its dependable grip . . . no amount of shock or vibration can shake these nuts loose.

Elastic Stop Nuts not only protect against vibration, but the Red Elastic Collar also keeps bolt and nut threads rust-free . . . does not gall bolt threads . . . and permits easy removal for replacement and repair.

Here's a Challenge: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Or, if you want further information, write for literature.

Elastic Stop Nut Corporation of America, Union, N. J. Representatives and Agents are located in many principal cities.

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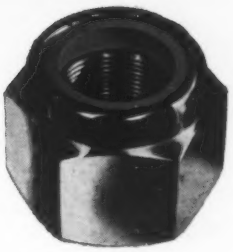


THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. Protects against nuts loosening due to VIBRATION
2. Keeps locking threads CORROSION FREE
3. Provides for accurate BOLT LOADING
4. Seals against LIQUID LEAKAGE along the bolt threads

ELASTIC STOP NUTS

INTERNAL WRENCHING

ANCHOR

WING

SPLINE

CLINCH

GANG CHANNEL

NYLON CAP

OVER 450 TYPES AND SIZES IMMEDIATELY AVAILABLE FROM STOCK

ACE

John R. MacKay tells:

HOW TO RECOGNIZE A JOB FOR HARD RUBBER

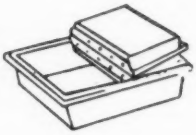
How can a man think straight about materials when so many new ones are always popping up. Now take hard rubber, for instance.

It's been all around us for nearly a century. Let's clamp down on our hard rubber pipe bits, ease ourselves down on our rubber casters, and take a good look. From an impartial viewpoint. (*We* can, because Ace molds *both* hard rubber and other important plastics).

First, we see dozens of grades of hard rubber, and they're all different. Generally speaking, they're black beauties, easily polished, with a real nice feel. *Good* for handles, grips, pipe bits, knobs, combs, etc.

We see it's tough, stable stuff that's well nigh impervious to water and 'most all known chemicals. (Except mineral oils and organic solvents— but Ace *synthetics* take care of them.) Its resistance to water is topped only by Ace polyethylene.

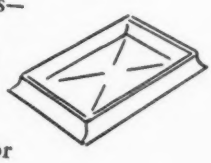
Tensile strength of hard rubber is up with the best plastics—up to 9,700 psi. Coefficient of expansion is very low—good for refrigerator parts. For the hot spots, we can give you compounds that won't distort up to 250° F., but don't count on more than 150° from any general purpose mix.



You probably know all about the top-notch electrical properties of hard rubber. But did you know its wear resistance is so good it's often used in bearings? So tough it's used in bowling balls.

Add it all up—Ace hard rubber is good for a lot of things—water meter parts, magneto parts, foot tubs, vinegar dumpers, fountain pen parts, sparges (if you know what *they* are) and chemical piping. It's probably natural for a lot of things you make, too.

Want to know more? Just tell me your problems or ask for a copy of our new Hard Rubber and Plastics Handbook.



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modynamic principles and engine cycles precedes introduction of supercharging compressors. A certain amount of design data for centrifugal and turbo superchargers is included with descriptions of constant and variable speed drives and the effects of different altitudes on the aircraft engine.

Since it is necessary to estimate the conditions in the engine manifold, to develop the desired output, together with the air flow under all operating conditions before considering the design of a supercharger, one chapter is devoted to this subject.

Elements of supercharging the diesel engine are also considered. Both constant pressure and dual cycles are discussed.

The volume is extensively illustrated by pictures, diagrams and charts. An exhaustive bibliography suggests additional sources for information concerning supercharger and related engine design.

Molybdenum Steels-Irons-Alloys

R. S. ARCHER, J. Z. BRIGGS, *and* C. M. LOEB, JR. 391 *pages*, 6 x 9 *in., Published by Climax Molybdenum Co.*, 500 *Fifth Ave., New York* 18, *N.Y.*

Publication of this text obviously was undertaken with one aim in mind: to make available to the metallurgist and designer a handy reference on molybdeum and its effect on the properties and heat treatment of iron, steel, and various alloys. That the authors have accomplished their aim is apparent from even a casual glance through the book.

The text is divided into ten sections. The first three of these deals with the general heat treatment of steel and cast iron: the various transformation phases that occur during the heat treatment of these materials; the effect of molybdenum on the microstructure and properties; the basic forms of molybdenum that can be added; and the processes that can be used.

The remaining seven sections deal with specific molybdenum-containing iron, steel, and alloys. Wrought alloy engineering steels, wrought corrosion resistant steels, wrought steels for elevated temperature applications, tool steels, castings, and cast iron are covered. The last section is devoted to special purpose and non-ferrous alloys.

Charts and tables are copiously used throughout the text, and a bibliography at the end of each section gives specific references to publications and transactions of the technical engineering societies that can be consulted for more detailed information.

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OUR READERS SAY

What Price "Streamlined Beauty"?

To the Editor:

The adjective "functional" nowadays is supposed to declare that the object so described is made for performance only, any ornamentation per se being deliberately omitted with Spartan severity. Inherent beauty is believed to result automatically. You can place bets with confidence that the word functional is frequently used defensively because of criticism expressed or implied of the appearance of anything from a gadget to a large building. Also modern designers in their passion for being functional are apt to forget just what the functions of their brain children are.

Take for instance the modern automobile. The average person wants a vehicle that he can enter easily, even with his hat on; that he can park readily; and that will afford him a better view of the country through which he is riding than that provided a person standing up in a bus. He would be grateful if the car were so designed that he could keep it dent free with reasonable care.

An article in the "Saturday Evening Post" on the Puget sound ferries written after cars had attained their present length stated that the capacity of the boats for carrying motor vehicles had been reduced around thirty percent. It is reasonable to suppose that available parking spaces in towns and cities has been reduced an equal amount. That is no joke these days. If cars get much longer, means will have to be found to stand them up on end when they are left at the curb. The amount the cars stick out behind the rear wheel is a nuisance and a source of danger. When a car is backed into a parking place at the curb one runs the risk of hitting a light pole or removing city property such as parking meters or a P.D. sign. The long extension can cause difficulty in leaving or entering a moderately steep driveway, when the bumper scrapes on the pavement.

The difficulties presented the motorist offer many incentives to double parking, and bad parking such as running the nose of the car against the curb and leaving the rear end out in midstream. It is getting so that driving through a shopping center is an

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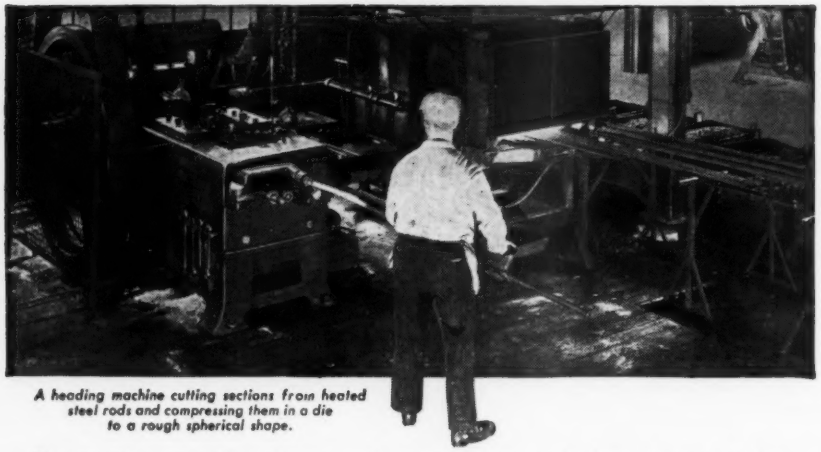

A heading machine cutting sections from heated steel rods and compressing them in a die to a rough spherical shape.

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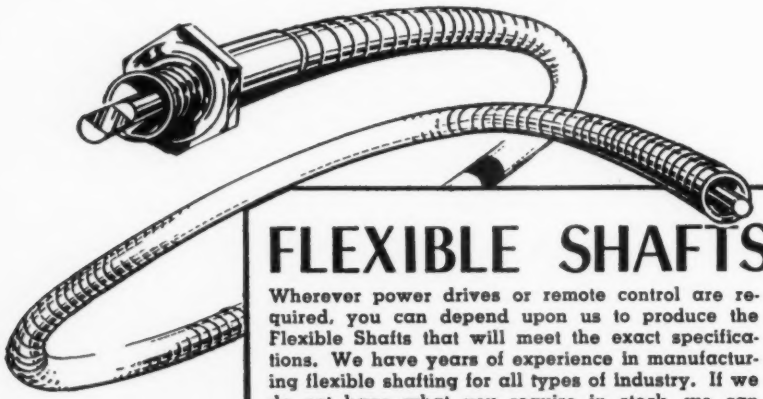

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aggravation and an incitement to the use of unprintable language.

The vogue for carrying the sides of the car out even with the mudguards hasn't made parking lots any more convenient. It used to be possible when cars were close together to swing the door of your car the width of the two runboards so that you could squeeze in. Now a safe breaker couldn't get in one of the new cars when left close to another. A practical scheme for preventing some one from driving up inches from your car when you are in the movies or a restaurant does not immediately present itself.

The acrobatics required to wiggle across the wide front seat, and under the low roof of the new cars make drivers more prone to get out of the left hand door; and step out into the traffic, a procedure safety experts don't exactly approve of. Whose heart has not jumped up in his throat when the left hand door of a parked car has swung open practically in his face when he was threading a tortuous passage through congested traffic?

If car doors get much lower, they will be accessible to Dachshunds only. Nowadays if you wear a hat most likely the door lintel will knock it off. If you don't, you run the chance of being brained. Having negotiated the entrance to the car, you reach out to close the door only to find that it is aground on the curb or mired in the nearby terrain. If the passion for reducing the height of cars continue you will have to ride bellywhopper and steer with a bar across the front like a Flexible Flyer. There are now cars that don't permit a person who sits erect to wear a hat when in the back seat.

The scant head-room in the back seat is frequently aggravated by the "streamlining" of the car; and is but one of the sacrifices to comfort and safety made in the name of that fad. Some years ago a prominent motor car manufacturer was quoted to the effect that contemporary car bodies were built in the tradition of the old coach makers and were therefore affected and antiquated. At this time a great deal had been said in popular publications about the fairing of airplanes, so what could make a motor car more "functional" and modern than to fair or streamline its body? Some of the early streamlined models were slightly ridiculous, like one car with a long slopping back with the spare tire mounted on it, certain to break up any streamline flow that might develop.

One of the first modifications of the body to satisfy the streamliners was to slope and then divide the windshield. Sloping the windshield does not have any appreciable effect on the

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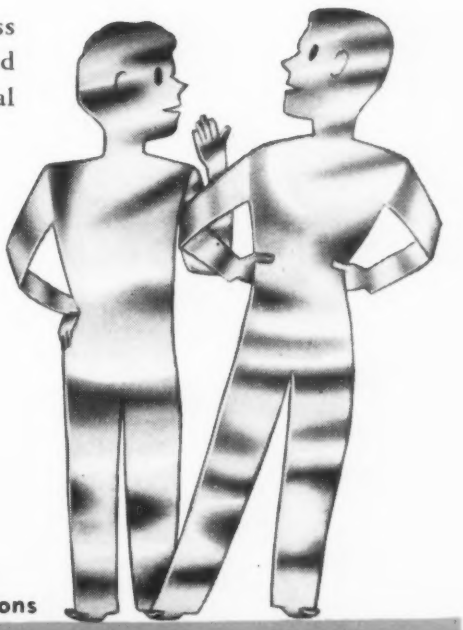

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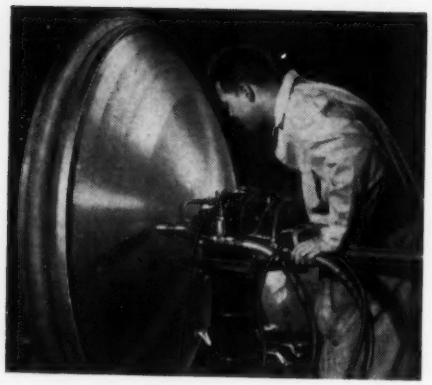

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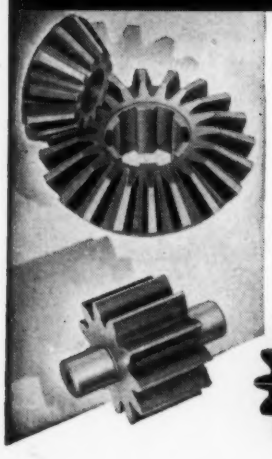

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light transmitted through it when clean but as soon as it gets a little bit dirty it becomes less efficient than the nearly vertical one. However, it does allow more of the hot noonday sun to shine on your lap.

Some windshields are so much sloped that in a heavy rain the water is forced up the windshield making the windshield wiper ineffective. Sloping windshields and back windows increase the problem of keeping these areas free from snow. In some of the cars the back window is little more than a skylight.

Windshields and back windows on a slant make it tough on the drivers of other cars since they can reflect at least twenty-five percent of the direct sunlight into the eyes of a driver of a closed car on a bright summer day and can cause a defect of vision that persists for a period depending on the individual. It used to be that when bothered by glare from the rear window of a car, a driver could move to one side or the other of his lane and avoid the nuisance; but the ever resourceful car designers took care of that. They rounded the glass at the rear window so no matter what you do, you have a bright bar of light dancing in front of you.

Sloping the windshield and rounding its corners has increased the size of the blind spot made by the left-hand front corner post of the body. It can mask dangerously a car coming from your left and close. The old cars may have been antiques by comparison, but you could see something of the scenery as you went by.

Last winter around New York was, to resort to the vernacular, a humdinger, and what made going worse was the car without skid chains. True a lot of people thought that they would never need them, and lots were discouraged from applying these helps to traction by the neat little paddle boxes built around the rear wheels of their cars. In addition to making chain application difficult, if not impossible, these rear wheel covers make it difficult to get an idea of the condition of one's rear tires.

Another effect of streamlining is to make the engine much more inaccessible. Local garages have reported an increase in burns because of the resulting awkward construction. It would also seem natural for the quality of engine work to suffer as the mechanics' difficulties increase.

Headlights are handy things to have on a car, particularly at night, and a lot of states are so unreasonable as to expect you to have two in good working order. With this in mind the car designers placed the headlights in about the most vulnerable spot they could think of, the front corners of

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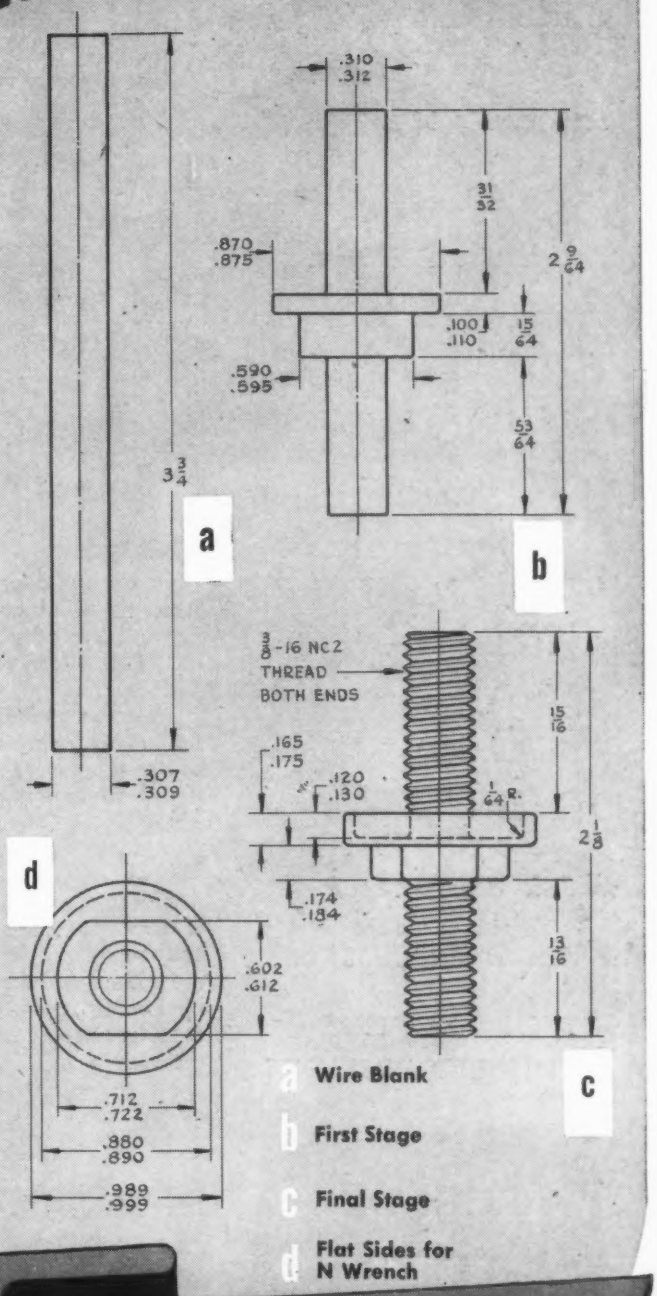

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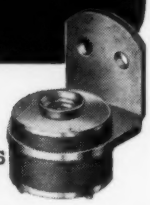

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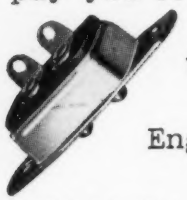
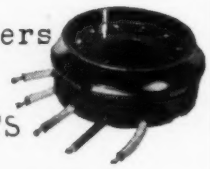


the Design Engineers of United-Carr and its subsidiaries. They have helped many manufacturers



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the car. How many cars have you seen with the left hand light flaunting a sightless socket without even a black patch to conceal its raw injury?

In fact, the whole car has become most vulnerable since the fenders and body have merged. From front to back the side of the car is unprotected. The bodies of the old, unfunctional automobiles were protected front and back by a bumper that could absorb some of the shock imposed on it because it was fastened to the chassis by steel. On each side was a stout running board flanked by fenders none of which were too expensive to replace. The head lights were set back from the front bumper and inboard from the fenders, so that these sources of illumination had a chance for survival.

With the new style cars a slight injury to the runningboard can jam a door, and be very expensive to repair. The height that the runningboard is from the ground makes damage from rocks and curbs more likely than with the older, higher ones. Damage of this sort has even been caused by the frozen ridges left by snow plows. Of course, there are many country roads that are not navigable by these modern vehicles.

A minor, but silly result of streamlined styling is the door construction on a number of two-door sedans. The rear door post slants forward above the window line. This leaves the rear edge of the door glass unsupported when the window is lowered the least bit, and also presents a nice target for your head when you try to get in the back seat.

Of course, whether you like the appearance of the new streamlined cars or not is a matter of taste, but the fact that a slight bump can cost a lot to repair is a different matter, because taste doesn't enter into anybody's dislike of repair bills. All this is reflected in the cost of car insurance, so if your premiums increase by leaps and bounds don't get your agent on the phone and try to remove his ear by remote control; just address your remarks to those anonymous gentry in the vicinity of Detroit who dream up the fashions that we must accept in motor vehicles.—GEORGE CAWLEY.

Spring Formulas

To the Editor:

The article by Mr. A. Bodenschatz entitled "Formulas for Spring Redesign" published in the April issue of PRODUCT ENGINEERING is interesting from a purely mathematical point of view, but certain caution should be taken when the formulas are used in actual practice.

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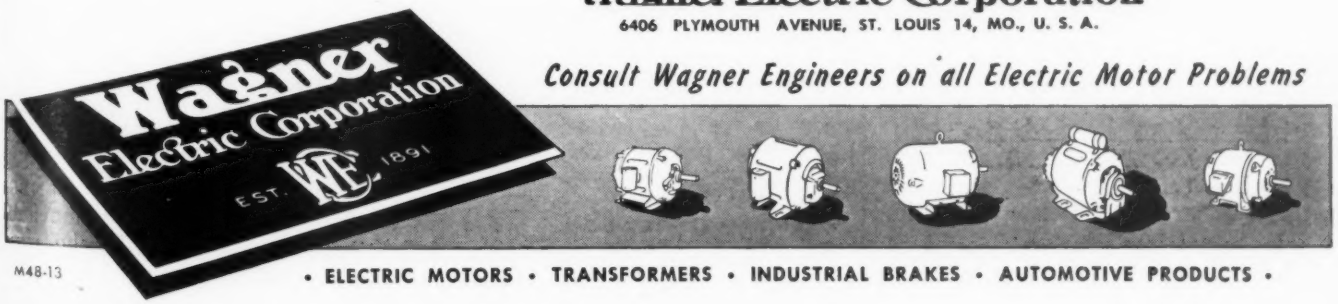

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formulas, the well-known correction factors have not been introduced. Let the ratio of external diameter of the spring D to the diameter of spring wire d be

$$c = \frac{D}{d},$$

the stress correction factor be

$$\frac{c + 1.25}{c - 2} + \frac{0.615}{c - 1},$$

and the deflection correction factor be

$$1 + \frac{1}{2(c-1)} - \frac{1}{2(c-1)^2}$$

It is necessary to introduce both factors into the derivative of K.

Further, the solid height of the spring also comprises a number of inactive coils, depending upon the number of active coils. For checking stress, factors of structural safety and actual strength of spring material in torsion should be considered.

I do not recommend the use of a fictive mean diameter of the spring, preferring to operate with the actual external diameter. To me, graphical methods provide spring designers with a simpler means for solving complicated problems.—VICTOR TATARINOV, *Consulting Engineer, Pilsen, Czechoslovakia.*

Nylon-Coated Wire Rope

To the Editor:

The Highlights Section of the August PRODUCT ENGINEERING contains a short item about Nylon-Coated Wire Rope. We are very much interested in such a product and would like to have you advise us whom we might contact for further information about this development.

—R. S. MILLER, *Hydra-Line Div., Hydraulic Engineer, Johnston Enterprises*

Ed.—The nylon-coated wire rope was developed and is being manufactured by Rochester Ropes Inc., Culpepper, Virginia. They designate this product by the tradename "Wirelon".

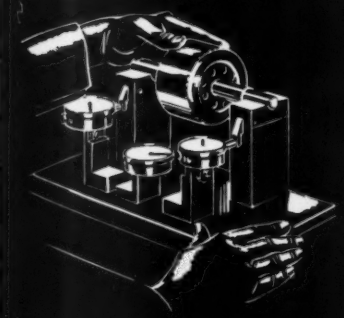
An Expensive Conversion

To the Editor:

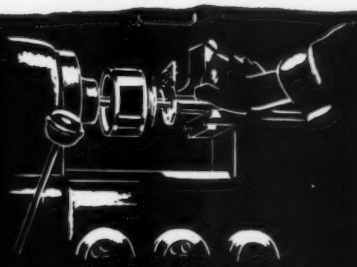
The old question concerning the desirability of adopting the metric system is much like the bad coin that turns up now and then.

We have read the abstracts from "British, American and Metric" by Curtis L. Bates, appearing in the September issue of PRODUCT ENGINEERING, and suppose that it is inevitable that some individual will make a nuisance of himself, like the bad coin, by

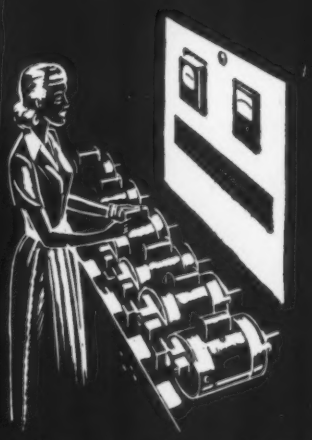
Why J&H means Reliability



l along the line, inspectors ecision-check motor parts.



Special machine double-checks starting switch.



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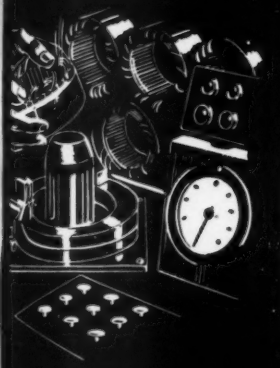
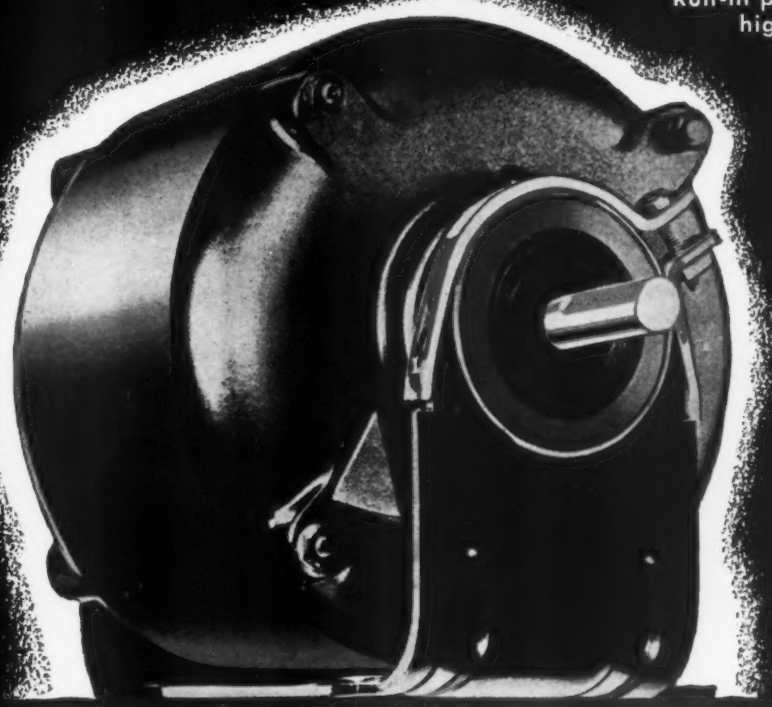


usive stator tester checks rformance of windings.



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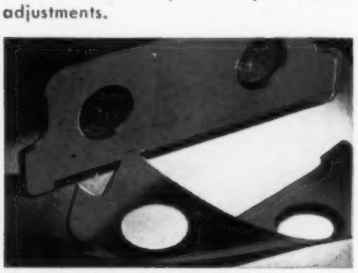
5 Cut to your exact specifications. Less than 1% rejects over the years.



The remaining "solid" shim is always uniform in gauge, with a hard surface . . . clean and smooth as glass.

6 Can be fitted with babbitted lugs to prevent oil and pressure loss.

7 No new skill required for use.

8 Your customer recognizes the plus value of less "down time" for maintenance and adjustment.

Send today for chart illustrating 46 money-saving, time-saving applications, detailed specifications, sample of LAMINUM.

PRECISION STAMPINGS in any quantity

Let us quote on your *difficult* stamping jobs. Our experience, tools and presses are geared for *close tolerance* production.

* LAMINUM (Reg. U. S. Pat. Off.) shims are solidly bonded laminations of .002 or .003 inch precision gauge brass or steel with a microscopic layer of metallic binder. Cut to your exact specifications.

LAMINUM — THE SOLID SHIM THAT peels FOR ADJUSTMENT

LAMINATED SHIM COMPANY, Inc.

1412 Union Street Glenbrook, Conn.

SHIMS SHIM STOCK STAMPINGS AN-COR-LOX NUTS

attempting again and again to sell the metric system to the American public.

Because of the importance and far reaching economic bearings of changing to the metric system, it would meet strong opposition from industry just as it always has in the past.

A bill to make the metric system compulsory in the United States after January 1, 1901, was introduced in the House of Representatives March 16, 1896, and was reported favorably by the Committee on Coinage, Weights and Measures, but it did not come to vote on the floor and died a natural death from inattention. Similar bills were introduced since but met the same fate.

The American Society of Mechanical Engineers has gone on record as opposing compulsory adoption of the metric system after making an extensive survey on the subject in 1903. In testimony concerning the Britten Bill in 1926, John R. Leighty of the Southern Railway estimated that the initial cost of such changes to the railways would be $333,000,000 and $80,000,000 per annum for many years to follow. It has been estimated that as much as $1,500,000,000 would be required to change from the English system to the metric system.

In view of the recrudescence of prometric propaganda, two interesting and worthwhile books are recommended for a clearer understanding of the problem, "System of Weights and Measures" by Walter Renton Ingalls and the National Industrial Conference Board's Report Number 42 entitled "The Metric Versus the English System of Weights and Measures".

To sum it up, as aptly expressed by Mr. Walter Renton Ingalls, President of the American Institute of Weights and Measures, "A century ago, when our records were relatively few, that might have been done here, as it was done in other countries, but the passage of every year laces us more inextricably and more irrevocably with the past".

—GEORGE E. ROWBOTHAM
Standards Engineer
American Coach & Body Co.

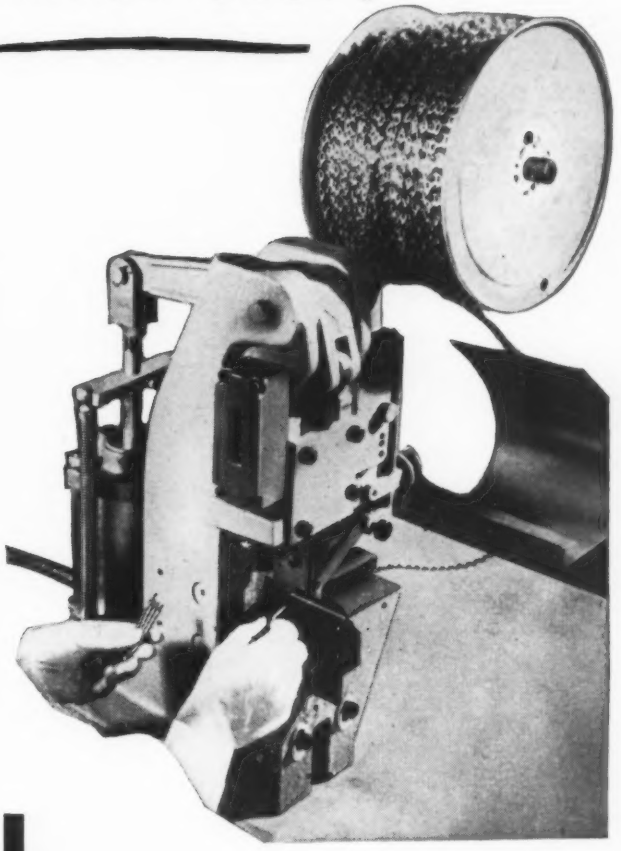
Metal Finishing Handbook

To the Editor:

In checking over the review given our annual Metal Finishing Guidebook and Directory by various publications, I note in reading the one which appeared in your March 1948 issue that the price of the book is given as $150.

We would certainly like to get this much for it, but the only charge is $1.50. This review certainly must have killed any possible orders which might

PUT THIS AMP AUTOMATIC WIRE TERMINATOR TO WORK IN YOUR PLANT WITHOUT COST!



The AMP-O-MATIC Wire Terminator is now LOANED WITHOUT COST on a one year renewable basis—to purchasers of 100,000 AMP Auto-Crimp Terminals of one kind.

You have a wide choice of AMP Auto-Crimp Solderless Terminals—pre-insulated, non-insulated, insulation support, and insulation piercing types—ranging in price from $2.50 per thousand to $17.14 per thousand.

Since the AMP-O-MATIC Wire Terminator installs terminals automatically, the cost of installing them is brought down to the irreducible minimum.

Do not hesitate to have your wiring program analyzed in terms of this AMP high speed automatic tooling. Actual cost reductions are significant.

Phone, wire, write, or clip the coupon below for complete literature, terminal types available, and data sheet.

Utilizing a continuous strip of solderless terminals and a completely automatic crimping cycle, the AMP-O-MATIC (pneumatic) Wire Terminator enables the average operator, without special operating skill, to achieve production speeds of 2000 or more finished connections per hour. Every connection is completely uniform.

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is ours—to show you how the AMP-O-MATIC will lower the installed cost of your wired connections. The first step is to mail this coupon.

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Whether used in small household appliances or huge machine tools, the dependability and uniformity of Perkins Precision Gears mean performance-stability in the finished product.

Precision engineering and manufacturing "know-how", backed by proper equipment have kept Perkins Gears tuned to the demands of many industries. In the interest of improved products, let us quote on your gear requirements. YOU FURNISH THE SPECIFICATIONS—WE'LL PRODUCE THE GEARS!

• **PERKINS MAKES, in all materials, metallic and non-metallic:** Helical Gears, Bevel Gears, Ratchets, Worm Gears, Spiral Gears, Spur Gears, Ground Thread Worms

PERKINS MACHINE & GEAR CO.
SPRINGFIELD 2, MASS.

have resulted. In a few weeks we will send you a copy of the 1948 edition to be reviewed. —PALMER H. LANGDON,
Assistant Publisher,
Finishing Publications, Inc.,
New York 18, N. Y.

Ed.—Our sincerest apologies for this error in proof reading. Thanks for calling it to our attention.

Aluminum Boat

To the Editor:

In the July 1948 issue of your magazine, we noted under "Highlights" an article which mentioned that an aluminum boat hull has been drawn in one piece, 12 feet in length. We are very interested in such an operation as this and would be extremely grateful if you could afford us with more detailed information as to the company performing the job, address, etc.

—PETER P. WHALEN,
Sales Promotion,
Permanente Products Co.,
Oakland 12, Calif.

Ed.—The aluminum boat hulls are made by a competitor of yours, The Reynolds Metals Co., Louisville, Ky.

Sponge Rubber

To the Editor:

I want to congratulate you on the new section in PRODUCT ENGINEERING called "Highlights." It should prove to be a very interesting feature.

On page 5 you had an item about new sponge rubber. Will you please give me any further details you have on this. —L. B. BENHAM,
Porter-Cable Machine Co.,
Syracuse, N. Y.

Ed.—Drop a line to the Commonwealth Engineering Co., Dayton, Ohio.

Cylinder Wall Coating

To the Editor:

I would appreciate learning where to obtain the cylinder wall protective coating mentioned on page 106 of the June PRODUCT ENGINEERING.

—F. G. BROEKER,
Mechanical Dept.,
Braden Copper Co.,
Rancagua, Chile

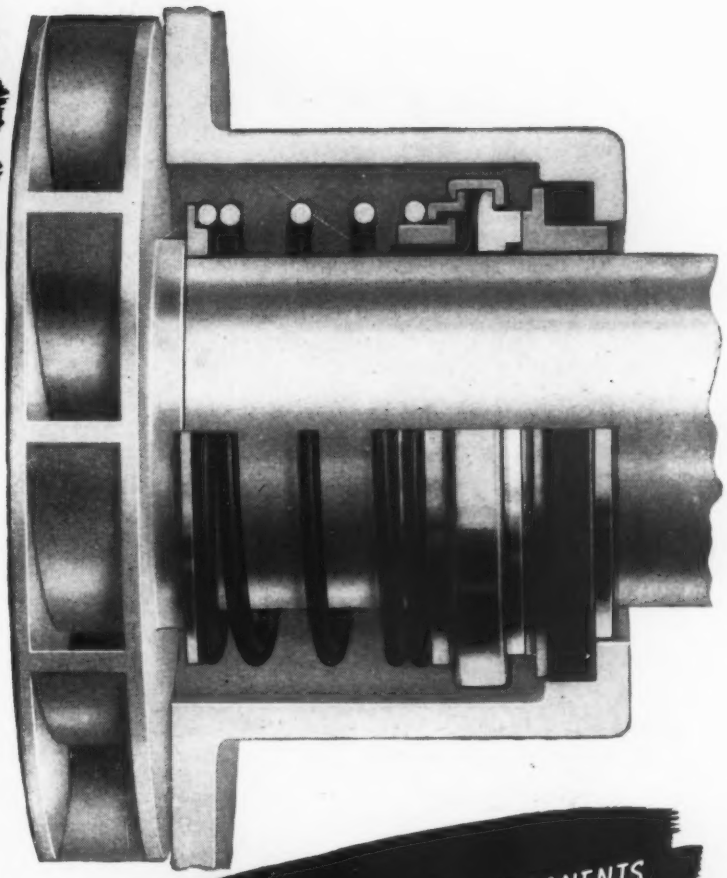
Ed. — Write to the Dodge Div., Chrysler Corp., Detroit, Mich.

Non-Destructive Testing

To the Editor:

Please send me further information on the non-destructive testing for fatigue damage mentioned in your "Highlights" section, page 7, of the

ADVANCED DESIGN in SHAFT SEALING



GITS ROTO-FLEX SHAFT SEAL

ADVANCED DESIGN . . . Key to the development of Gits Bros. new ROTO-FLEX SHAFT SEAL. And back of this development lies the detailed research and experience gained by Gits Engineers over many years of designing and manufacturing high speed shaft seals.

The advanced design features of the Gits Roto-Flex Shaft Seal include:

1. No loose parts—permanently assembled Seal Nose.
2. Positive built-in flexibility.
3. Torque washer that relieves diaphragm strain.
4. Balanced design—Minimum spring pressure.
5. Machine-lapped seal surfaces.
6. Easy installation due to extreme construction simplicity.

AVAILABLE SINGLE OR DOUBLE. The single Gits Roto-Flex Shaft Seal is employed where liquid to be sealed can act as a lubricant or coolant, and the double is for those applications where additional liquid must be supplied to the seal chamber for lubricating or cooling purposes.

The need for the Gits Roto-Flex Shaft Seal is unlimited and UNTIL NOW not fully answered. For proper recommendations on your seal problem, send a dimensioned drawing, showing where the seal is to be applied, for immediate and careful attention by Gits Bros. Engineers. Also include such operating data as:

1. Shaft R.P.M. and direction.
2. Liquid or gas being sealed.
3. Temperature range.
4. Pressure range.

and any special details related to design or assembly. On any shaft sealing problem—as on any lubricating problem—it will pay you to consult with Gits Bros. . . . "Friction-Fighting Headquarters" for over 40 years.

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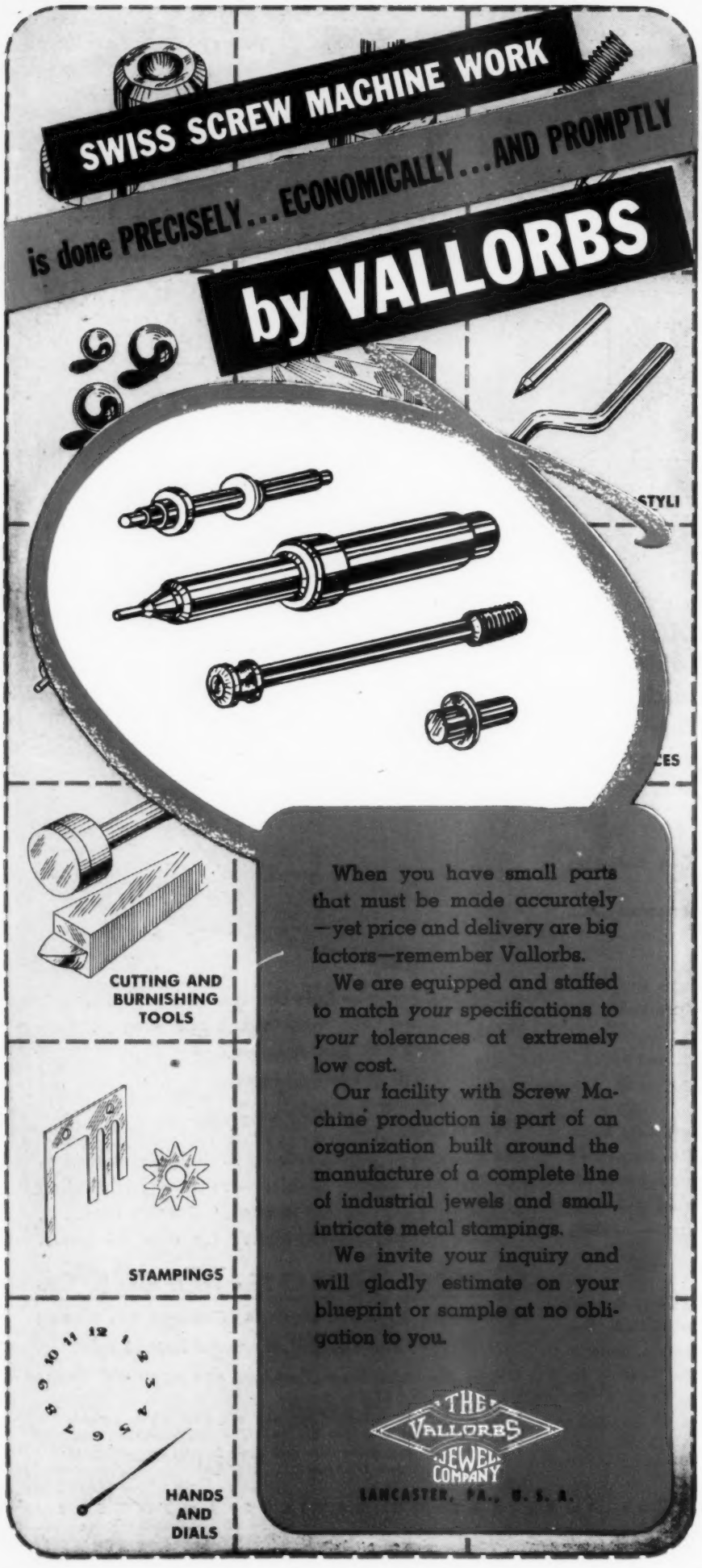
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LANCASTER, PA., U. S. A.

August, 1948 issue of PRODUCT ENGINEERING. —J. E. RYAN,
General Electric Co.,
Schenectady, N. Y.

Ed.—Full information can be found in Preprint No. 30 of a paper presented by J. B. Duke before the June 1948 meeting of the American Society for Testing Materials.

Preprints are available from Society headquarters: 1916 Race St., Philadelphia 3, Pa.

International Ore Bridge

To the Editor:

My eye was caught by the third paragraph, right hand column, on page 7 in the Highlights section of your August issue. You mentioned a 575 foot, 15-ton ore bridge of riveted and arc welded construction that was described as having been built in England. I am sure that your readers will be interested in knowing that the description of this bridge exactly fits a bridge built last year by an American firm, the Dravo Corporation of Pittsburgh, Pennsylvania, for use in the U. S. A. —GEORGE MERRILL,
Pittsburgh, Pa.

Stress Analysis Studies

To the Editor:

I am sorry that no mention of Stresscoat was made in Part II of my article entitled "What Kind of Information Does Brittle Coating Give?" as it appeared in the July issue of PRODUCT ENGINEERING. This coating material, manufactured by the Magnaflux Corp., was used in all my stress tests.

—A. J. DURELLI,
Research Engineer,
Armour Research Foundation

Ed.—We are glad to bring this to the attention of our readers.

Plastic Nipples

To the Editor:

In the June issue of your very valuable and informative journal PRODUCT ENGINEERING we observe on page 104, it is possible to obtain laminated phenolic nipples in varying diameters and lengths. We should be glad if you would ask any manufacturer of these items to send us a range of samples together with technical details.

—A. C. R. GREENE,
Dartmouth,
Devon, England.

Ed.—Write to the Adlet Mfg. Co., Cleveland 11, Ohio.

BALDWIN
IMPLEMENTS THE *NEW TREND* IN STATIC TESTING

(*Above*) New 5,000,000 lb. machine at left. At right is a 600,000 lb. Baldwin machine.

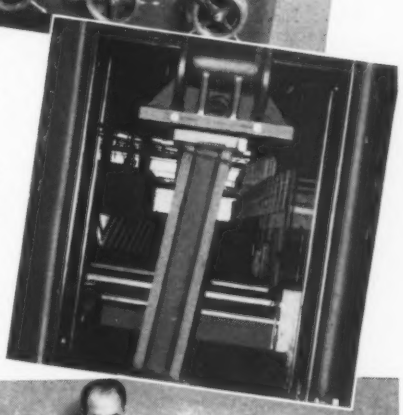
The largest universal testing machine in the world, built to Navy specifications by Baldwin, is now at work in the Aeronautical Structures Laboratory at the Philadelphia Naval Base. It is capable of applying loads of 5,000,000 pounds in tension and compression, on specimens up to ten feet wide and thirty feet long. Flexture loads may be applied to structures up to 50 feet long.

Initial assignment of the new machine is in the field of aircraft development. Full-sized simulated aircraft structural members and assemblies of aluminum and magnesium will be tested. The aim is to achieve the optimum in shape, weight and strength and also to develop factors to take care of "size effect," thus permitting more trustworthy projection of test-specimen results, and making model testing a more accurate basis for design.

Engineers today are increasingly reluctant to assume direct correlations between tests of small specimens and performance of large sections or structures, and are demanding verifying evidence—which can only be provided by large capacity machines. To meet this requirement, Baldwin has built and installed eight other universal testing machines, with capacities of 1,000,000 to 4,000,000 pounds. The effectiveness of these new tools has been magnified many times through use of the Baldwin SR-4* strain gage, which accurately reports the stress pattern in the part under study.

If full-scale testing has become an essential in your business, Baldwin will be glad to discuss your problem with you.

(*Above*) "Nerve center" of the new testing machine. Large dials show load.



(*Right*) Eccentric load test produced only a fraction of allowable deflection.

(*Below*) An 8-in. test specimen it snapped under a 4,200,000 lb. load.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U.S.A.
Offices: Boston, New York, Philadelphia, Houston, St. Louis, Chicago, Cleveland, Pittsburgh, San Francisco, Seattle, Washington. In Canada: Peacock Brothers, Ltd., Montreal, Quebec.

*Trade Mark Registered U. S. Patent Office

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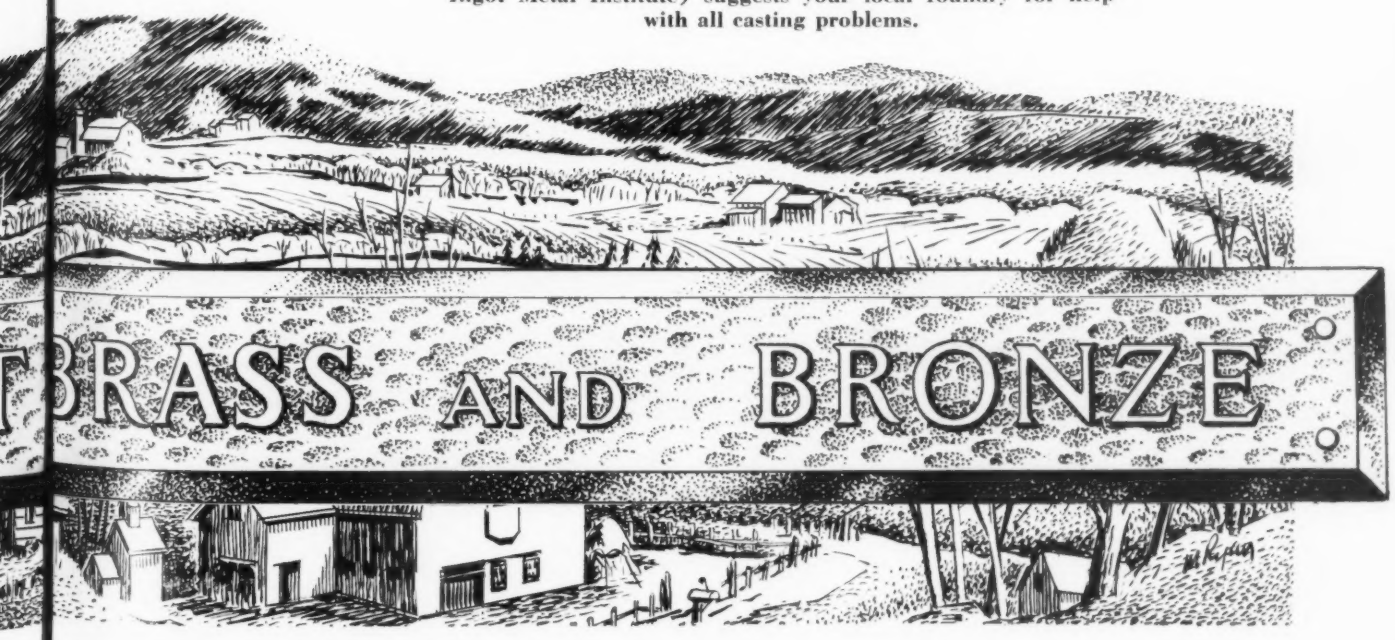
Brass and Bronze

For richness of tone in centuries-old bells . . . for strength and endurance in industrial castings . . . for beauty and permanence in architectural use . . . cast brass and bronze are top choice of leading designers everywhere.

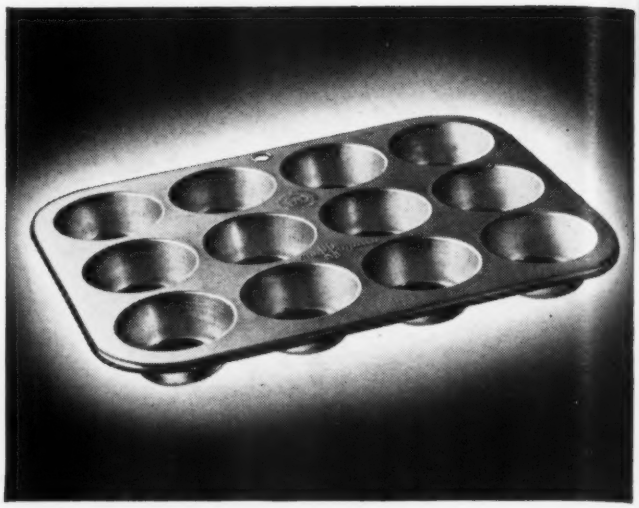
Those who mold the character of our modern buildings . . . architects, designers and decorators . . . know the desirable effects that can be achieved with the traditional metals. Engineers choose them for countless purposes where the important considerations are freedom from corrosion, great strength, and reliability throughout long service.

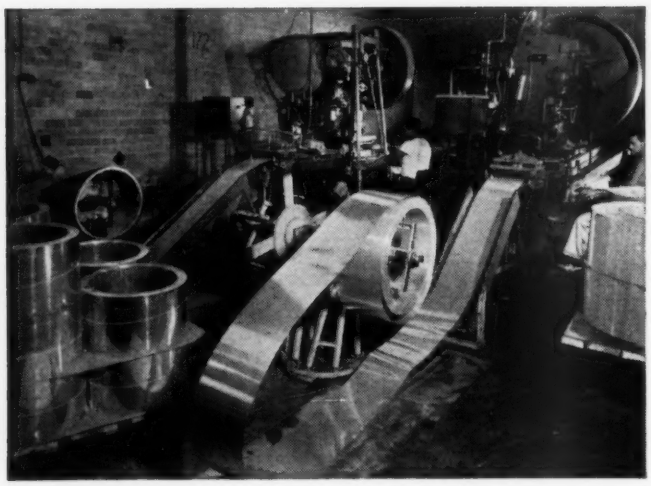
Specify brass and bronze castings . . . they are available NOW!

The Brass and Bronze Ingot Institute (formerly Non-Ferrous Ingot Metal Institute) suggests your local foundry for help with all casting problems.

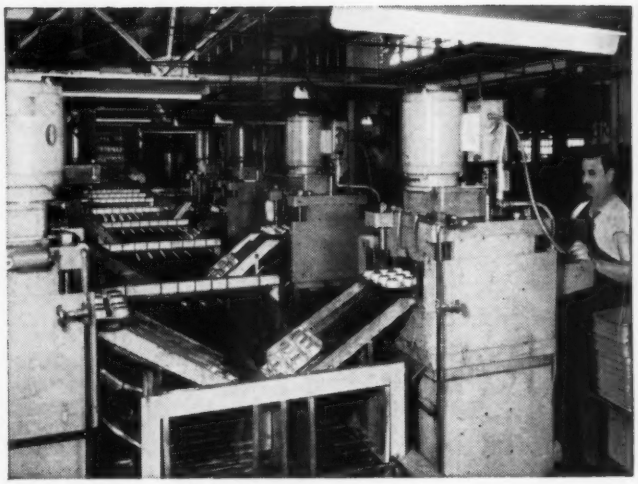


SPUN FROM A BLANK IN 9 SECONDS!





THE LIGHT WEIGHT muffin pan at the top is *seamless*. It's the "Muffinaire," and it's made by United Aircraft Products, Inc., Dayton, this way: Mill coils of the proper alloy of Kaiser Aluminum are automatically fed into 50 ton presses. In one quick operation the aluminum is blanked to size, flanged, and stamped with trade name and patent numbers. At this point it is ready for the spinning of the cups.



COLD BLANKS are placed in these special spinning presses and finished pans are automatically ejected *in from 6 to 9 seconds!* In that brief period 12 uniform cups have been *spun* to make a muffin pan that's strong, rustproof, and an excellent heat conductor. By conventional methods it would have been necessary to draw each cup separately, then attach them individually to the pierced blank.

Like United Aircraft Products, Inc., *you* can lower fabricating costs with the proper alloy of Kaiser Aluminum.

You can save manufacturing steps and handling costs because of its consistent high quality and workability. You can cut scrap losses, too. And you can obtain a lasting, bright finish by merely buffing!

You'll have a product that has eye-appeal, *sell*-appeal. That can't rust, warp, chip, crack. That's light, durable.

For *your* most difficult fabricating problems, call in a Permanente engineer. He can help you select the right alloy of the *versatile* metal—Kaiser Aluminum!

For another dependable source . . . choose

Kaiser Aluminum

product of Permanente Metals Corp.

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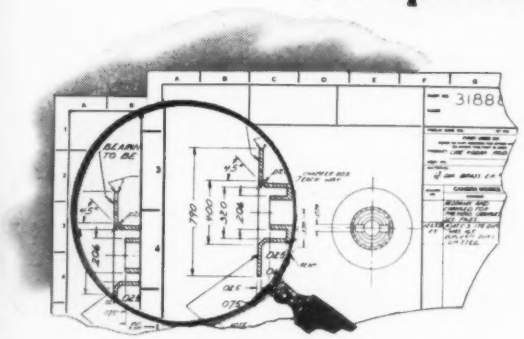

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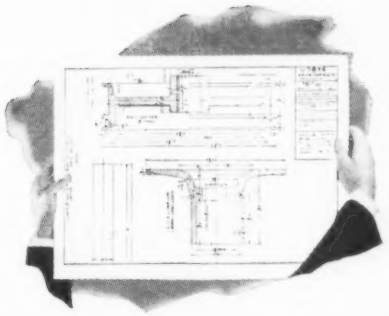

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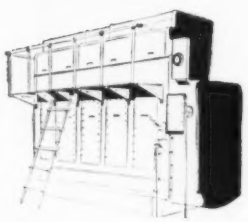
You'll find unusual combinations of physical properties to meet your needs for improved product performance and appearance in Continental-Diamond high-strength plastics. Take *Celoron*, for instance, used in the gear shown here. This versatile material provides strength, resiliency, light weight, as well as moisture, heat, and corrosion resistance. Moreover, it is readily workable . . . can be tapped, drilled, shaped, milled, and threaded with ease.

And *Celoron* is but one of many C-D materials that can help to add new advantages to your product. Whatever your application, see Continental-Diamond first for recommendations that lead to higher product quality and appearance . . . lower fabrication costs. Your nearest C-D office has trained technicians with additional information that will interest you. Call or write, any time.

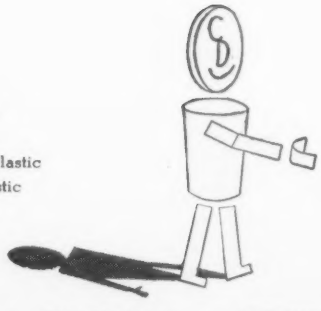


Another C-D Case of Improved Performance

Making a huge, 2-foot timing gear for Diesel Locomotives always presents problems. The gear had to be strong enough to stand terrific strains —yet resilient enough to absorb shock. Dimensional stability, quiet performance, and easy machining were basic requirements. *Celoron* is proving its ability on applications like this, and a host of others where mechanical precision and rugged operation are needed.

DIAMOND FIBRE—Vulcanized Fibre
VULCOID—Resin Impregnated Fibre
DILECTO—Laminated Thermosetting Plastic
CELORON—Molded High-Strength Plastic
MICABOND—Bonded Mica Splittings

DM-4-48



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THE STORY BEHIND ACCURACY TO SPARE

The many products to which cold-drawn seamless tubing is now being applied require accuracy from any number of standpoints. For pointer tubing, the instrument manufacturer wants precise strength-to-weight ratio for balance and to withstand striking a stop pin. For Bourdon gauges, shape, size, and metallurgical properties must be accurate for reliable indication of the slightest pressure variations. The mechanical pencil manufacturer requires dimensional accuracy for perfect fit of component parts. The electronic user seeks concentricity for coaxial conductors. How ever the tubing is used, all manufacturers usually stress one characteristic that must be carefully observed in tubing production.

Accuracy is no accident. Its fulfillment requires a production system in which supervisors fully understand the use to which each length of tubing will be put. Production men, in turn, must be instructed properly and must possess specialized skills to carry out such high standards.

Tooling, for example, can be only the best. No makeshift practices can be tolerated. Moreover, these tools must be checked frequently to make certain they are in perfect condition with duplicates ready if needed.

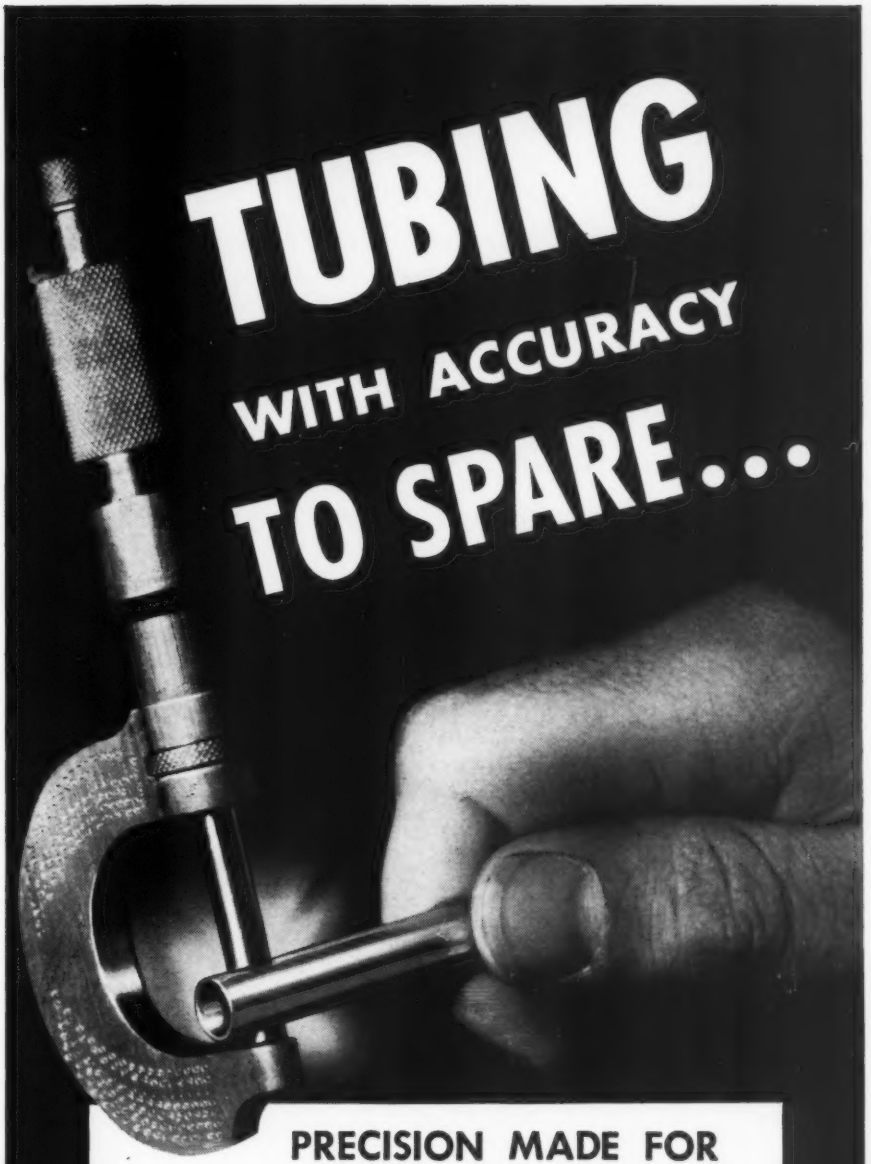
The metallurgist's position in maintaining accuracy is highly important. He must properly specify heat and load cycles for each anneal and take responsibility for conformance of the finished material with the customer's order.

The chemist is also important in Precision Tubing manufacture. His contribution of knowledge of lubrication and cleaning methods are vital to tool wear. Top accuracy is impossible if tools change from the beginning to the end of a production run. If mineral base lubricants are used, sulphur content is vital. With water soluble lubricants, staining is a major problem. In either case, proper cleansing methods must be devised.

Finally, the inspector must be skilled in the use of instruments. He must have at his disposal all specifications and be able to apply his instruments so that only tubing which meet specifications is released.

Thus, it can be seen that Precision's production requires a combination of many skills. Each individual directly involved must possess years of know-how and the firm desire to do a good job. Accuracy to Spare must result from team work to spare in any industry.

(Advertisement)



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When you specify seamless tubing—whether it's for instrument pointers, Bourdon gauges, metal-shielded wire, mechanical pencils, or any one of a number of products—here, at Precision, accuracy is our watch-word. Inside diameter, outside diameter, wall thickness—all dimensions are held to close tolerances, often exceeding those specified. In this way the over-all accuracy you want in your finished products is consistently carried out in our part of their manufacture.

Sizes of Precision Tubing cover a range of outside diameters from 0.500″ to 0.010″, with wall thicknesses down to 0.0015″. Available in aluminum alloys, brass, copper, nickel, monel, or other non-ferrous alloys—each length of Precision Tubing can be preformed to the shape you specify . . . ready on good delivery.

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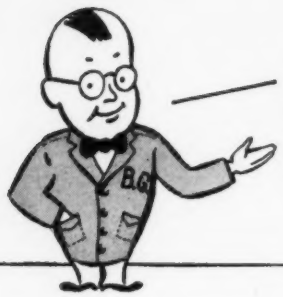

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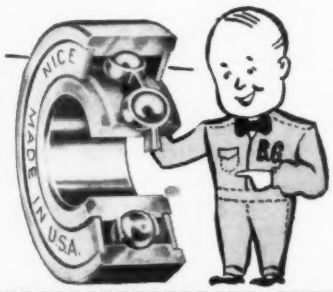

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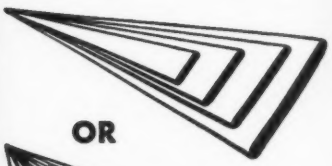

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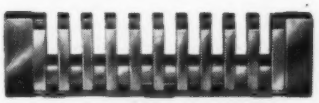
Typical parts molded on Stokes FULLY Automatic Plastics Molding Presses

Small Part for Hearing Aid

Simple Part for Bottle Seal



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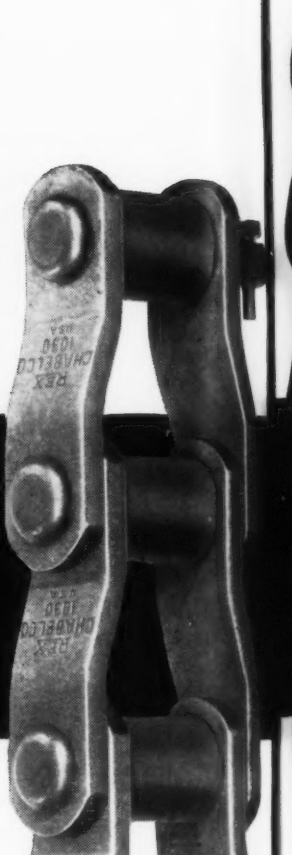
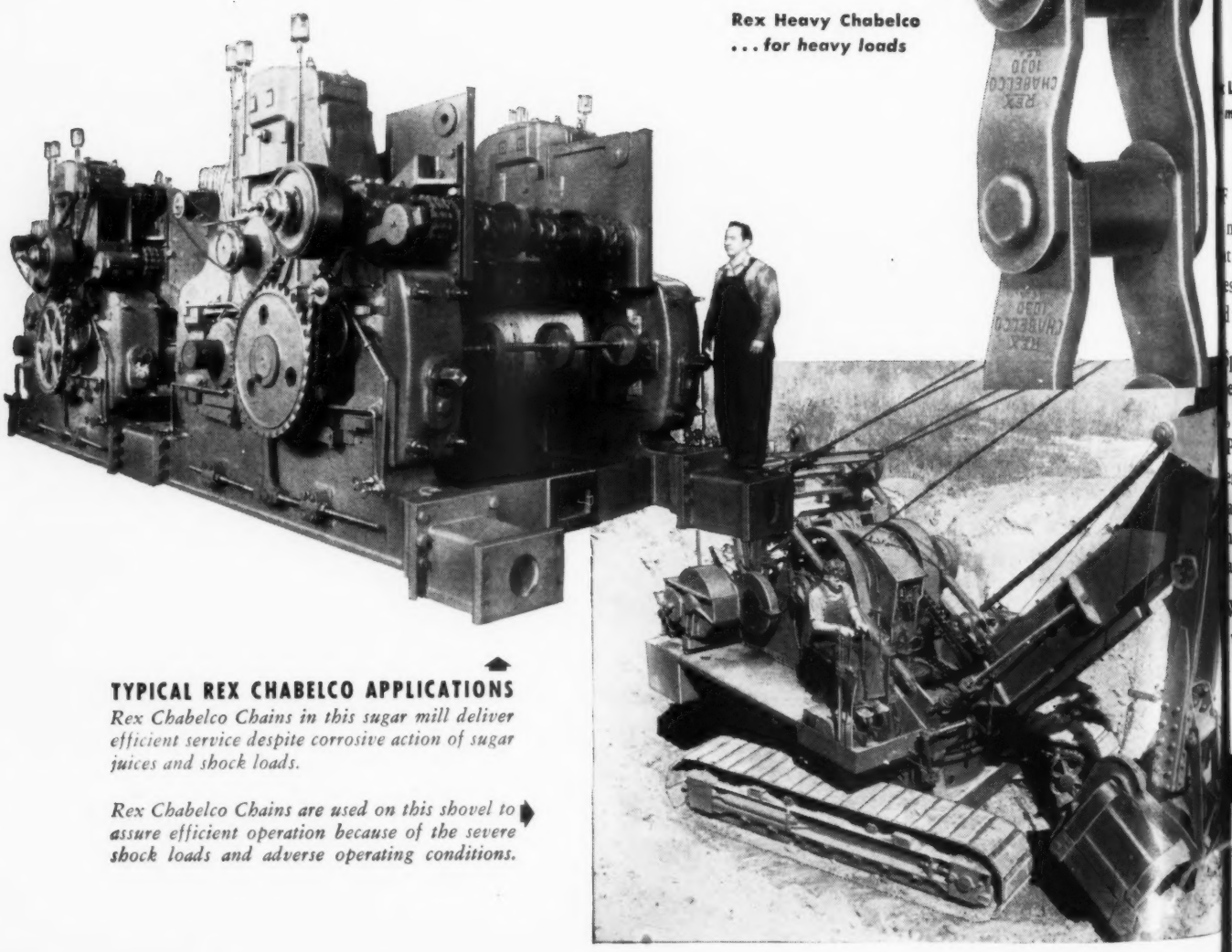


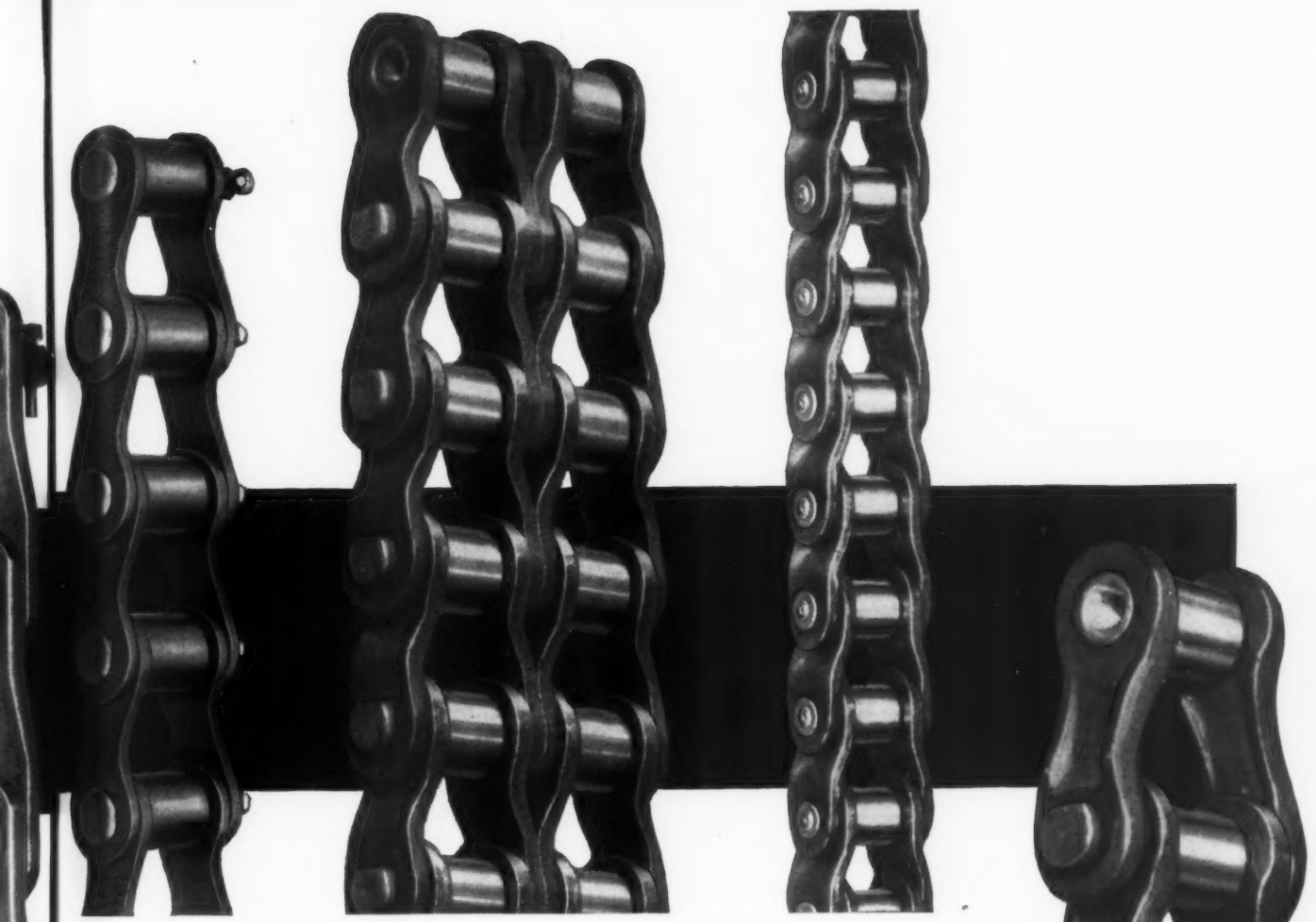
Rex Heavy Chabelco
. . . for heavy loads



TYPICAL REX CHABELCO APPLICATIONS

Rex Chabelco Chains in this sugar mill deliver efficient service despite corrosive action of sugar juices and shock loads.

Rex Chabelco Chains are used on this shovel to assure efficient operation because of the severe shock loads and adverse operating conditions.



Light Chabelco . . . ***moderate loads***

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Rex 3100 Series Chabelco . . . short ***pitch chain for high-speed service.***

Rex Champion Chabelco ***. . . for extra heavy loads***

f YOU'RE designing equipment that must operate under heavy loads . . . t is subjected to severe shocks and sses, the Rex Chabelco Line of Chains l Sprockets is "made to order" for you!

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Where service is exceptionally severe where equipment must operate under conditions of dirt, dust and temperature extremes, a Chabelco Chain will keep going when other driving mediums would soon fail. Designed-in clearances between working parts enable it to operate efficiently under these conditions and to accommodate minor misalignments.

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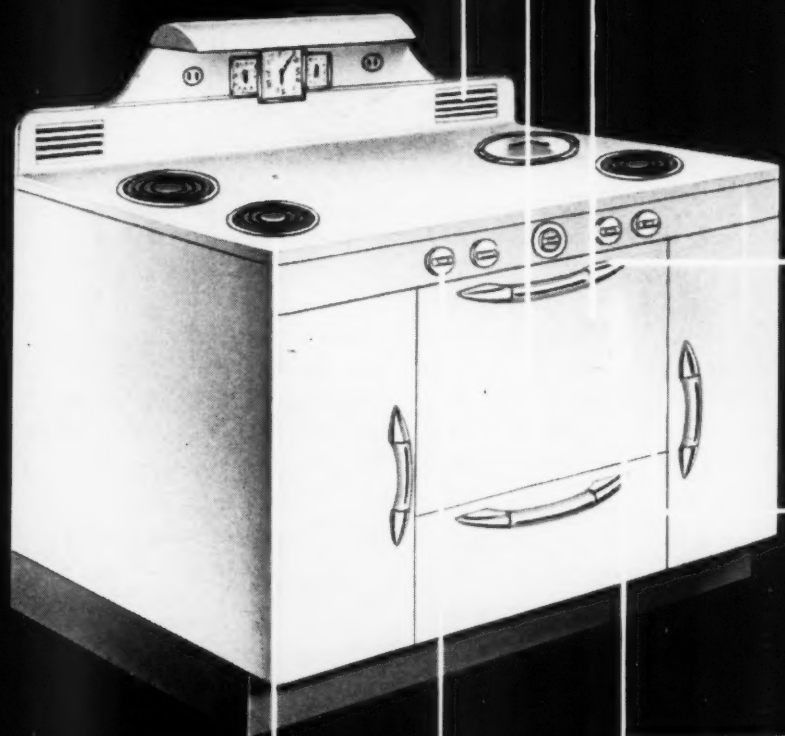
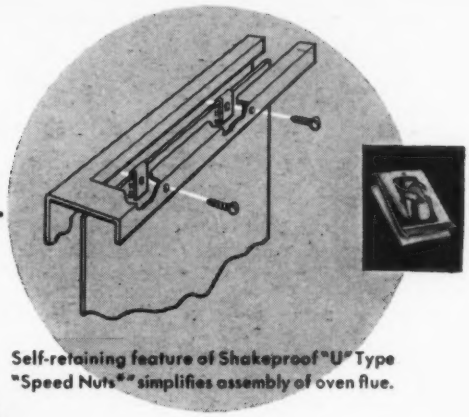
DRIVE AND CONVEYOR CHAINS

the modern kitchen range demonstrates the efficiency

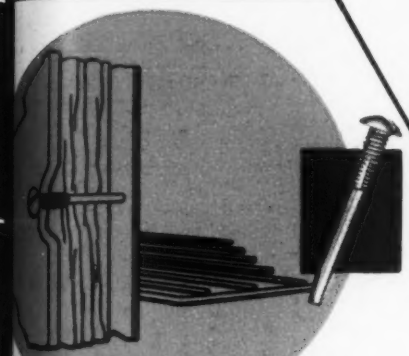
# of FASTENINGS by SHAKEPROOF



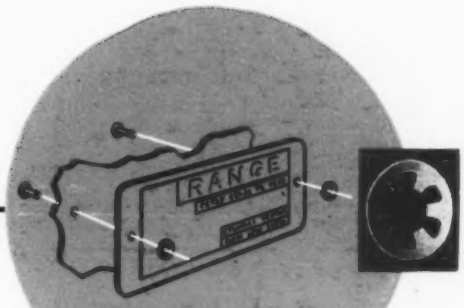
In every mass producing industry, Fastenings by Shakeproof have played an important part in assembly simplification and cost reduction. Typical of these fastening applications are the kitchen range assemblies illustrated on these pages. Developed jointly by Shakeproof Engineers and Range Designers and Production Men, they serve to demonstrate the assembly efficiency that can be achieved by close cooperation between manufacturers and fastening specialists. This free fastening service is available to *all* manufacturers on request. Write today.



Self-retaining feature of Shakeproof "U" Type "Speed Nuts"® simplifies assembly of oven flue.

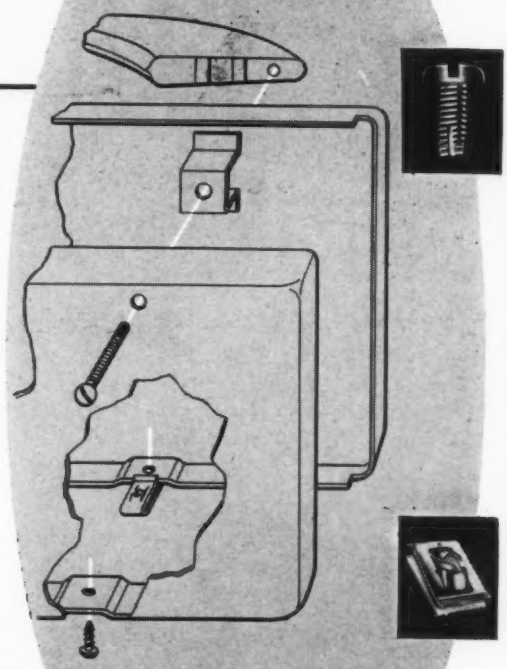


...l Shakeproof Thread-Cutting Screw ...s side panel, passes through insulation ...d provides alignment of oven liner.



Name plates are securely fastened with special Shakeproof Springrip Washers.

Door handle assembly is simplified with Type 1 Shakeproof Thread-Cutting Screws. Tapping of handle is eliminated.



Self-retaining "U" Type Shakeproof "Speed Nuts"® are used with Type "A" screws in door assembly.

WRITE FOR SAMPLES...

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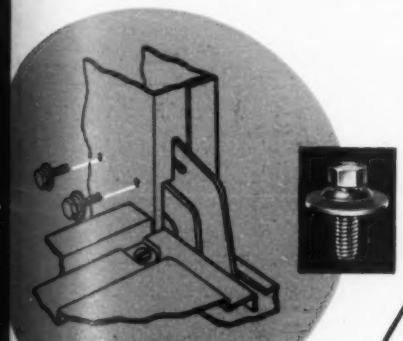
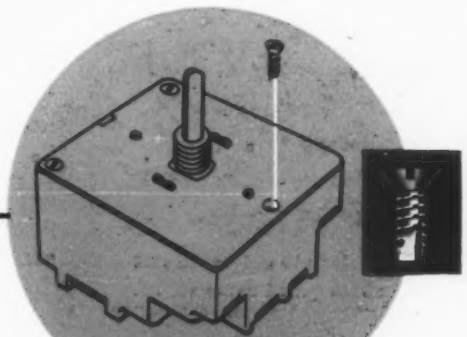
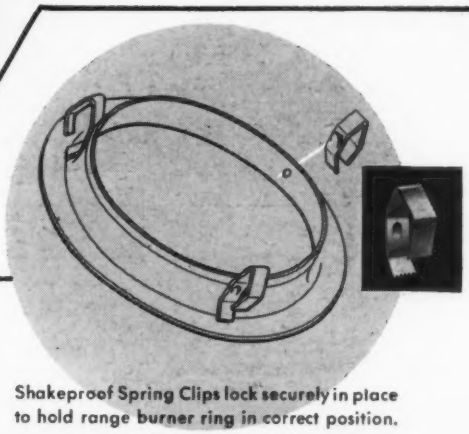


...sher Sems-by-Shakeproof hold oven ...r hinges securely even under heat expansion and contraction.



Shakeproof Type 25 Thread-Cutting Screws are used to fasten metal cover to plastic base of range switch.



Shakeproof Spring Clips lock securely in place to hold range burner ring in correct position.

...Reg. U. S. Pat. Off. Tinnerman Products Inc.

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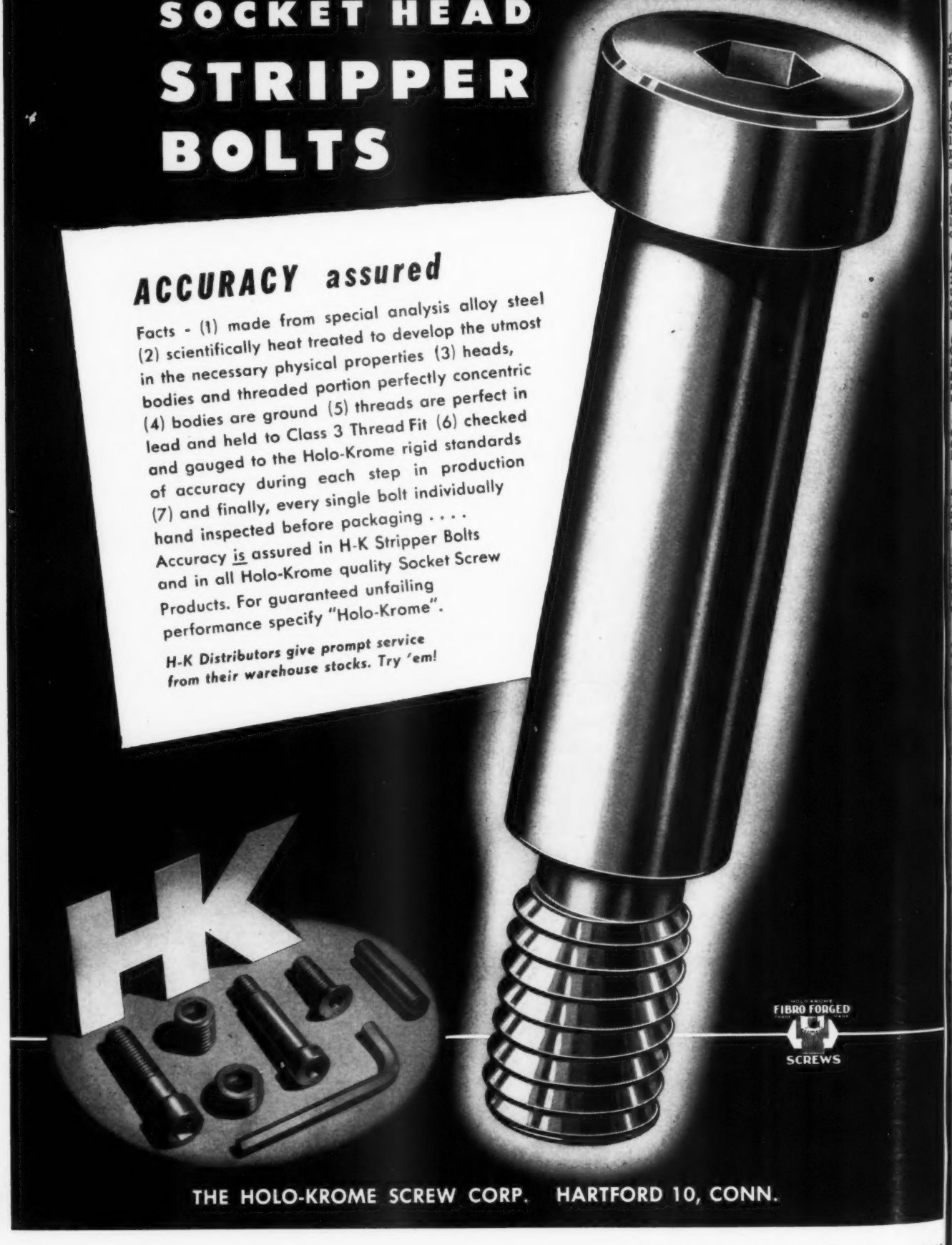
SOCKET HEAD
STRIPPER
BOLTS



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(34) METAL HOSE—Pennsylvania Flexible Metallic Tubing Co., 72nd St. & Powers Lane, Philadelphia 42, Pa. Bulletin 52-9, 19 pages. Pictorially records uses for steel and bronze hose, and contains tables to aid in selection.

(35) CENTRIFUGAL PUMPS—The Duriron Co., Inc., Dayton 1, Ohio. Bulletin 815, 20 pages. Covers Model 40 Series M pumps for handling corrosive solutions and gives information on pump convertability plus use of various accessories.

(36) DROP FORGINGS — Merrill Brothers, 56-02 Arnold Ave., Maspeth P. O., New York, N. Y. Catalog 1948, 20 pages. Contains engineering data for the selection of such industrial hardware items as turnbuckles, shackles and rivet eye bolts.

(37) PROTECTIVE COATINGS — Koppers Co., Inc., Tar Products Div., Pittsburgh 19, Pa. Catalog, 12 pages. Describes protective coatings and gives general information on surface preparation, coating thickness and methods of application.

(38) VIBRATION CONTROL — Korfund Co., Inc., 48-19-G 32nd Pl., Long Island City 1, N. Y. Bulletin G.-101, 4 pages. Contains descriptions of vibration control devices and tabulations for over 50 machines with the proper mountings for each.

(39 INDUSTRIAL SOLENOIDS—Detroit Coil Co., 439-447 E. Fort St., Detroit 26, Mich. Bulletin 481, 4 pages. Design data and specifications with line drawings to aid in selection.

(40) MOTORIZED SPEED REDUCER—The Falk Corp., Milwaukee 8, Wis. Bulletin 3105, 15 pages. Comprised of numerous tables with explanations as to uses for various models of compact, motorized speed reducers.

(41) PLASTIC ADHESIVE—Koppers Co., Inc., Chemical Div., Pittsburgh 19, Pa. Bulletin C-8-108, 4 pages. A report on the properties and application methods for Penacolite, adhesive G-1215, most satisfactorily used on structural timbers and other materials where resistance to outdoor weathering is required.

(42) CONTROL INSTRUMENTS — Wheelco Instruments Co., Chicago 7, Ill. Bulletin Z6500, 4 pages. Condensed listing of complete line of models for measuring, controlling and recording temperature, voltage, current and speed in industrial processing.

(43) METAL COATINGS—Enthone, Inc., 442 Elm St., New Haven, Conn. Bulletin, 6 pages. Describes black, corrosion-resistant Ebonol coatings for copper hand copper alloys, iron and steel, and zinc and zinc alloys.

(44) STEEL TUBING—Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill. Bulletin, 30 pages. Technical information on seamless and welded carbon-steel tubing, stainless tubing and pipe, and seamless and welded boiler tubes.

(45) FLOW TUBE—Bethlehem Foundry and Machine Co., Bethlehem, Pa. Folder, 6 pages. Combines cutaway views and engineering drawings to describe principle on which flow tubes operate, and incorporates cross-sectional and logarithmic charts showing the various results of calibration tests.

(46) STEREOSCOPIC MICROSCOPES—Bausch & Lomb Optical Co., Rochester 2, N. Y. Catalog D015, 19 pages. Well illustrated descriptions of 15 different models, including discussions on dust-proofing design, optics and positive focusing.

(47) AMPLIFIERS—Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn. Bulletin, 8 pages. Contains descriptions, specifications and applications for models of the laboratory-type, Microsen d-c amplifier.

(48) PYROMETERS — C. J. Tagliabue Corp., 614 Frelinghuysen Ave., Newark 5, N. J. Catalog 1101J, 37 pages. Detailed description of complete line of photoelectric pyrometers. Contains engineering data and many illustrations.

(49) TRANSFORMERS—Lindburg Engineering Co., Transformers Div., 2444 W. Hubbard St., Chicago 12, Ill. Bulletin 1110, 4 pages. Describes applications, design and construction of dry type transformers, and contains wiring diagrams for this equipment.

(50) PIPES AND FITTINGS — Saran Lined Pipe Co., 702 Stephenson Bldg., Detroit 2, Mich. Leaflet, 4 pages. Contains report on saran lined pipe and fittings with illustrations and table of pipe sizes.

HOW TO ORDER — Two post cards are printed here. On each is room for you to request four pieces of literature. If you are requesting four pieces or less, please use only the bottom card. For five to eight pieces use both cards.

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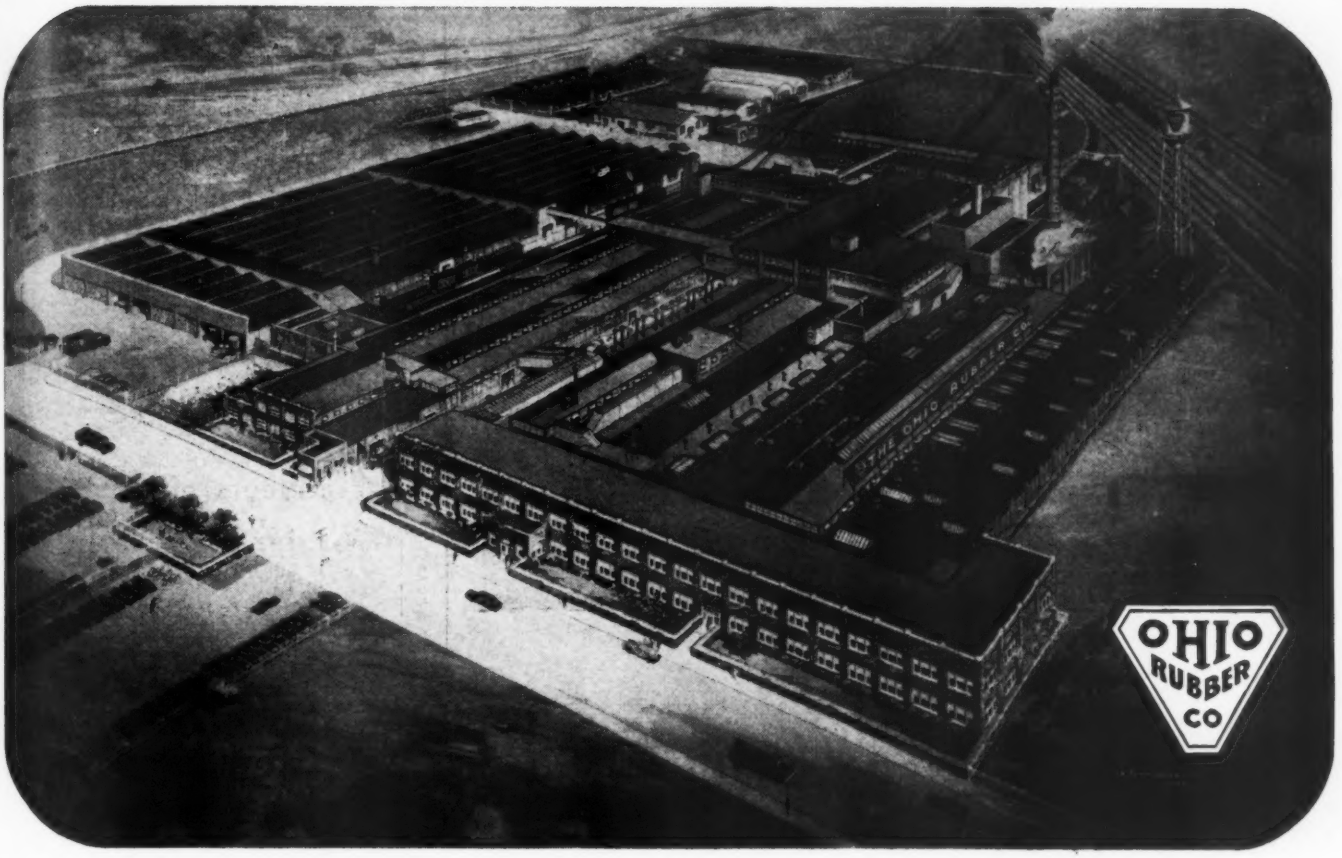

Main Offices and Factory of The Ohio Rubber Company at Willoughby, Ohio

14 ACRES OF "RUBBER KNOW-HOW"

(Specialists in Manufacturing to Customers Specifications)

"KNOW-HOW" is what makes the U. S. A. the greatest industrial nation in the world. Industrial "KNOW-HOW" is a combination of sound business management, practical research, advanced engineering practice, modern manufacturing techniques and, what is *most important,* the SPIRIT OF SERVICE as fostered under the American system of free enterprise. Those are the factors that developed THE OHIO RUBBER COMPANY to its present stature among the TOP TEN of several hundred manufacturers in the rubber industry.

THE OHIO RUBBER COMPANY

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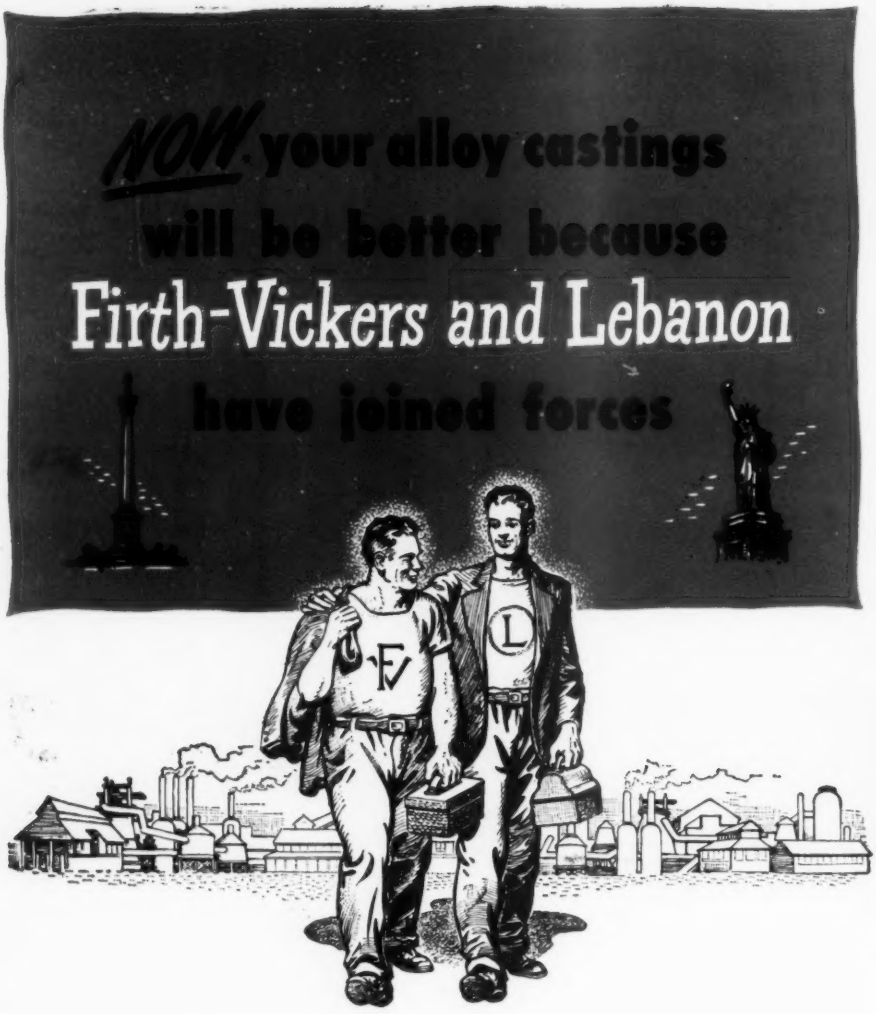

Corrosion and heat-resistant alloy steel castings of certain types acquire better characteristics when made by the Centri-die process in permanent molds This method was developed by Firth-Vickers of Sheffield, England, over a long period of experimentation. It is largely responsible for the superior qualities of the Rolls-Royce, De Havilland, Bristol and other British airplane jet engines. Since the war it has been widely applied to castings for corrosion and heat-resistant service.

The agreement between Lebanon and Firth-Vickers makes available to us the best experience, methods and foundry practices known in England and assures Lebanon's customers a continuance of our traditional high-quality standards.

If your equipment is subjected to high temperatures or corrosive conditions, you should know about the new Lebanon castings made by the Centri-die process in permanent molds.

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"Centri-die Centrifugal Castings"

Here is a clear explanation of the practical advantages to you of the Firth-Vickers Centri-die method of making alloy castings centrifugally in permanent molds. Of interest to executives and engineers who want to keep abreast of new manufacturing and production methods. Write for Bulletin L.

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"In The Lebanon Valley"

LEBANON ALLOY AND STEEL **Castings**
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Let us quote on your requirements.

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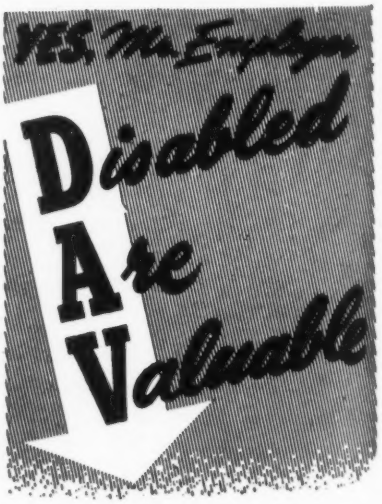
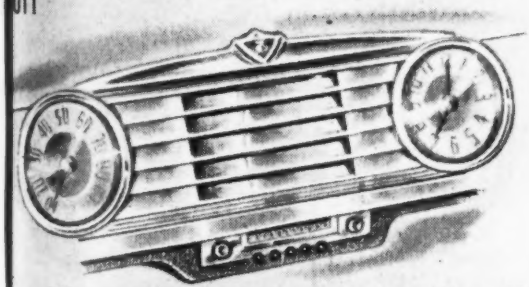
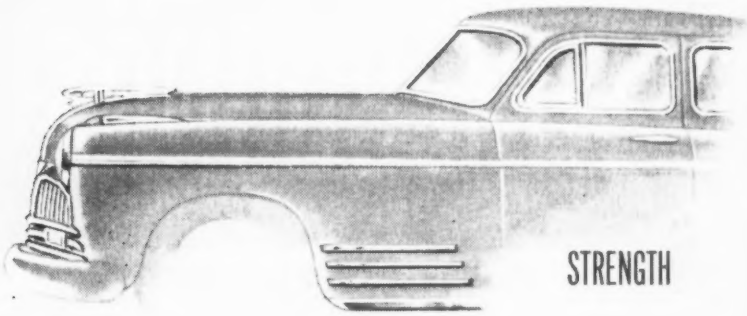


Out in Front

WITH SHARON STAINLESS STEEL

UTY



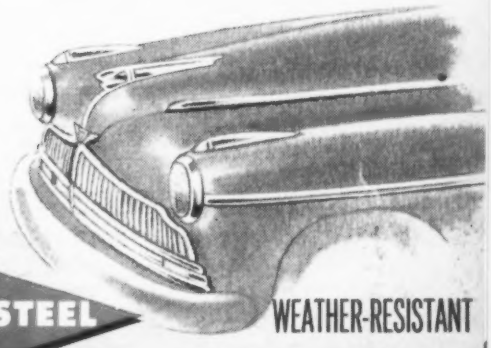


STRENGTH

The makers of automobiles, like all manufacturers whose products must have strength, beauty and be weather-resistant, are putting Sharon Stainless out in front where quality counts.

Sharon Stainless has a high resistance to rust and corrosion—retains its original finish year after year. It is many times stronger than plain steel—yet easily adaptable to almost any shape or form.

Small wonder then that Sharon Stainless leads the way where those who design tomorrow's products are concerned.



WEATHER-RESISTANT

SHARON STEEL CORPORATION

SHARON, PENNSYLVANIA

SHARONSTEEL

DUCTS OF SHARON STEEL CORPORATION AND SUBSIDIARIES: THE NILES ROLLING MILL COMPANY, NILES, OHIO; DETROIT TUBE AND STEEL COMPANY, ROIT, MICHIGAN; BRAINARD STEEL COMPANY, WARREN, OHIO; SHARONSTEEL PRODUCTS COMPANY, DETROIT, MICHIGAN, AND FARRELL, PENNSYLVANIA; PENTERTOWN COAL & COKE CO., MT. PLEASANT, PENNA.; FAIRMONT COKE WORKS, FAIRMONT, W. VA.; MORGANTOWN COKE WORKS, MORGANTOWN, VA. Hot and Cold Rolled Stainless Strip Steel—Alloy Strip Steel—High Carbon Strip Steel—Galvanite Special Coated Products—Cooperage Hoop—Detroit Seamless Steel ng—Seamless Steel Tubing in Alloy and Carbon Grades for Mechanical, Pressure and Aircraft Applications—Electrical Steel Sheets—Hot Rolled Annealed and Deoxidized Sheets—Galvanized Sheets—Enameling Grade Steel—Welded Tubing—Galvanized and Fabricated Steel Strip—Steel Strapping, Tools and Accessories.

TRICT SALES OFFICES: Chicago, Ill., Cincinnati, O., Cleveland, O., Dayton, O., Detroit, Mich., Indianapolis, Ind., Milwaukee, Wis., New York, N. Y., Philadelphia, Pa., Rochester, N. Y., Los Angeles, Calif., San Francisco, Calif., St. Louis, Mo., Montreal, Que., Toronto, Ont.

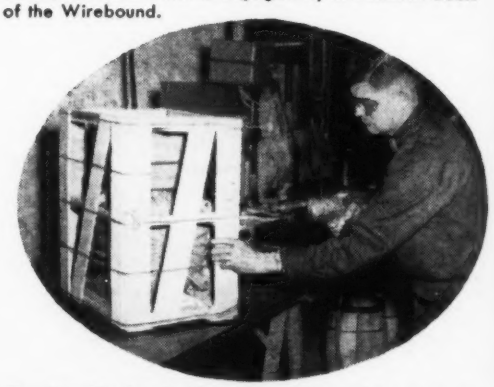
Leach Silo Unloaders, manufactured by the Leach Company of Oshkosh, Wisconsin are a boon to farmers in eliminating an unpleasant chore and conserving ensilage. But packing the 1200 pound, oddly shaped units in such a way that they could be handled and installed conveniently presented a difficult problem. Some method for shipping the machine as a group of sub-assemblies that would pass through small silo doors was essential.

Wirebounds solved the problem. Wirebound engineers "tailored" eleven different boxes and crates to package and protect the various parts of the unloader for safe, convenient shipping and handling. At the receiving end, re-assembly was easier because contents could be seen and identified through the sides of the Wirebounds for unpacking in proper sequence.

Light weight Wirebounds meant real shipping economy for Leach too. Less than seven man-minutes were required for packaging any one of the unloader sub-units and packed crates could be stacked 10 high to conserve valuable floor space!

Wirebounds can provide an efficient, economical solution to your shipping problems. Mail the coupon below!

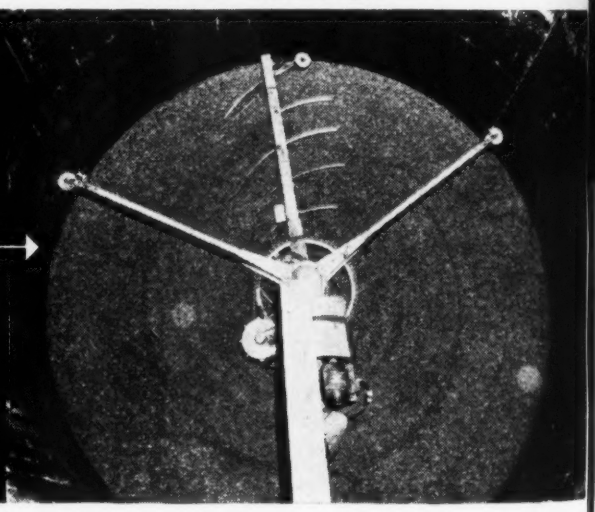
161 pound motor for the Leach Silo Unloader is mounted on a crate base which is engaged by the bottom cleats of the Wirebound.



The door-like fourth side is folded shut and the wires are twisted closed with an electric toggle twister.

another "ODD SHAPE" shipping problem solved by

WIREBOUNDS!



The unusual shipping problem encountered by the Leach Company is readily apparent in the above view of the assembled Silo Unloader.

▶ MAIL THIS COUPON TODAY

WIREBOUND BOX MFG. ASS'N.
Room 1820, Borland Building, Chicago, Illinois

☐ SEND COMPLETE LITERATURE ☐ SEND A SALES ENGINEER

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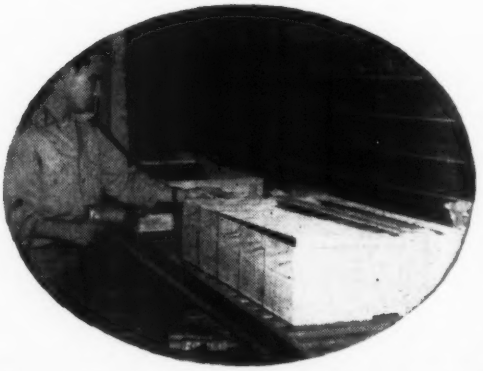
PRODUCT

SIXTY WIREBOUND PLANTS THROUGHOUT THE UNITED STATES

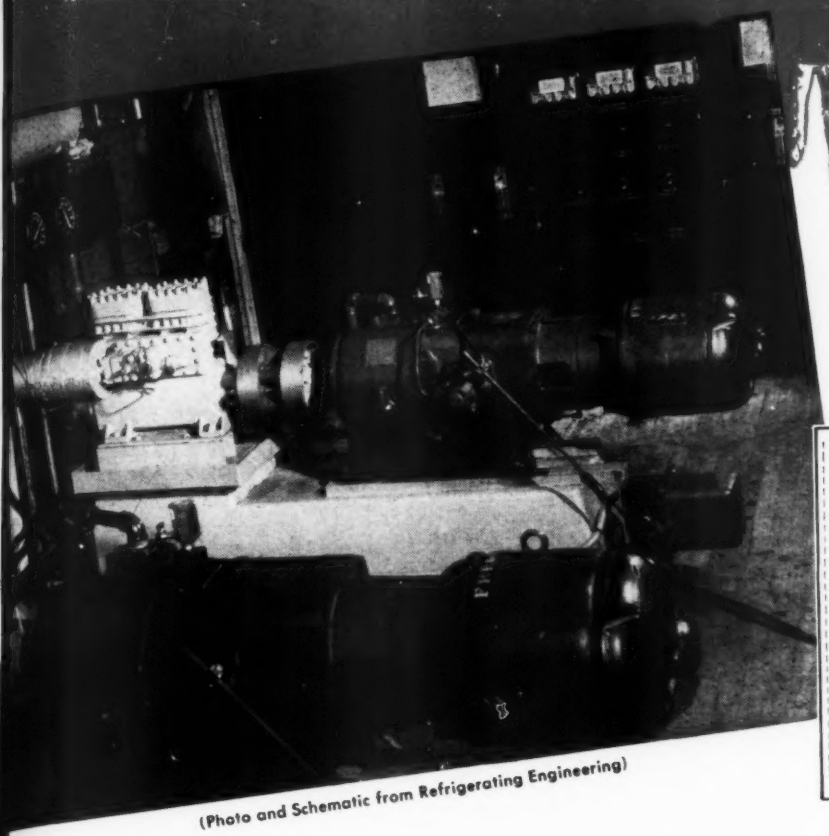
Wirebound BOXES & CRATES



Unpacking the 11 Wirebounds at the erection site is no problem since the twisted wire closures need only be cut to open.

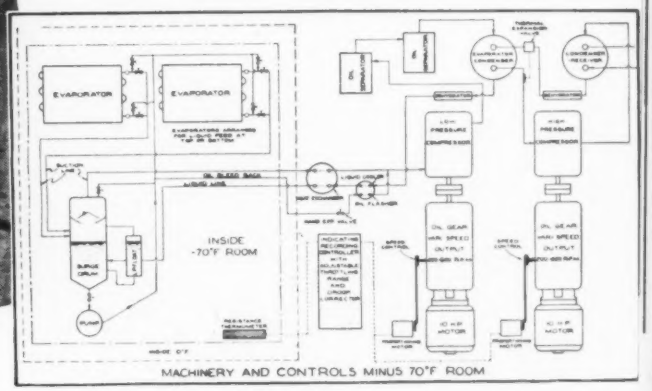
A STEADY 102° BELOW FREEZING

CALLED FOR CONTINUOUSLY VARIABLE SPEEDS AND STABLE OUTPUT TORQUE



(Photo and Schematic from Refrigerating Engineering)

Two Oilgear Fluid Power Transmissions driving compressors for research laboratory's —70 degree testing room. (Other Oilgear Transmission drives compressor for 0 degree room.) Output speed of transmissions varies according to temperature differential upon resistance thermometers. Control of speed is entirely automatic. Manual control for starting is optional. Oilgear Fluid Power Drives and compressors operate continuously. (See schematic below).



OILGEAR *Fluid Power* SOLVED THIS PROBLEM

The wide range of installations that demonstrate the reliability, scope and ease of control of Oilgear Fluid Power Drives and Transmissions grows daily. A case history from REFRIGERATING ENGINEERING, official journal of the American Society of Refrigerating Engineers, telling how a research laboratory chose Oilgear Transmissions and obtained continuous, dependable performance without delay, is another chapter in that story.

Demands for tests of materials at extreme temperatures called for equipment able to hold testing room temperatures stable at all times—usually at 70° F. below zero. It also had to refrigerate test materials as rapidly as possible. This meant a system of varying compressor speeds automatically—so as to compensate for variations in heat load.

Previous experience had shown that . . . the use of direct current motors, or variable speed drives of the belt-and-pulley type, under automatic control, was not entirely reliable and required considerable servicing.

Then Oilgear Fluid Power Transmissions were adopted. These transmissions provide continuously and automatically variable output speed and maximum output torque at all operating speeds. Nearly two years' experience reveals that temperatures have been maintained within ±½° F. of the desired figure over long periods of time, that no attendant is required except for a few minutes' daily routine inspection, that the Oilgear drives are completely reliable.

Thus the evidence grows that if you are tired of machine or process drives and transmissions that don't stand up, if you want simpler, better, more productive and dependable drives, if you have problems not yet solved, it will pay you to contact Oilgear Fluid Power engineers. THE OILGEAR COMPANY, 1311 W. Bruce St., Milwaukee 4, Wis.

Oilgear Fluid Power

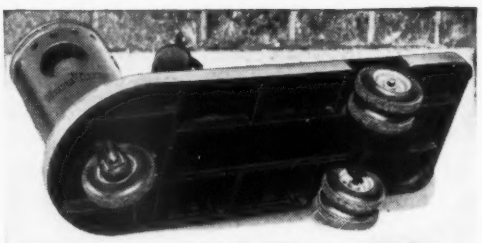
PUMPS, MOTORS
TRANSMISSIONS, CYLINDERS AND VALVES

1948

Cat-Quick in Action on GENERAL Industrial Pneumatic Tires

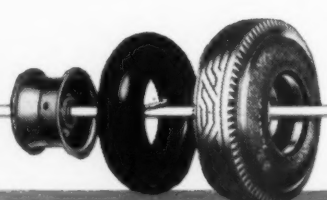
KWICK-TOTER moves loads faster!

For swift and complete maneuverability, in plenty of space or limited space, the all-new KWICK-TOTER fills a definite need. It will turn completely around in its own length; runs from 2½ to 10 mph; with dual wheels will carry 2-3000 pounds. Load area 23½ sq. ft. Overall weight 990 lbs. Length 108 in. Width 42 in. Kut-Kwick Tool Corp., Brunswick, Georgia.

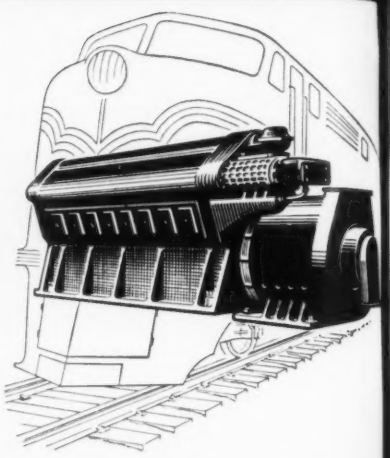


The most modern of the new materials handling equipment is being supplied with General Industrial Pneumatic tires. Available in complete assemblies of wheel, tube and tire, or tire alone.

The GENERAL TIRE



THE GENERAL TIRE & RUBBER CO.
Akron, Ohio



dieselization

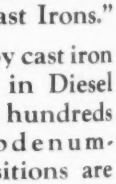
Diesel engines in railroad locomotives are piling up an enviable trouble-free performance record. Many castings in these engines contain specified Molybdenum contents.

When wear or heat must be resisted, and high strengths are required, the use of Molybdenum in cast iron is becoming more and more routine.

The listing of a cylinder liner for Diesel use in railroad locomotives containing 3.20% Carbon, 1.90% Silicon, 0.85% Manganese, with 0.20% Chromium, 0.40% Molybdenum and 0.45% Nickel added can be found on page 10 of our new booklet—"Applications of Molybdenum Cast Irons."

Dozens of other alloy cast iron compositions used in Diesel engines, as well as hundreds of other Molybdenum-containing compositions are similarly listed in this new booklet. Write for it!

Climax Molybdenum Company
500 Fifth Avenue
New York City



Please send your FREE BOOKLET "Applications of Molybdenum Cast Irons"

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Company.....

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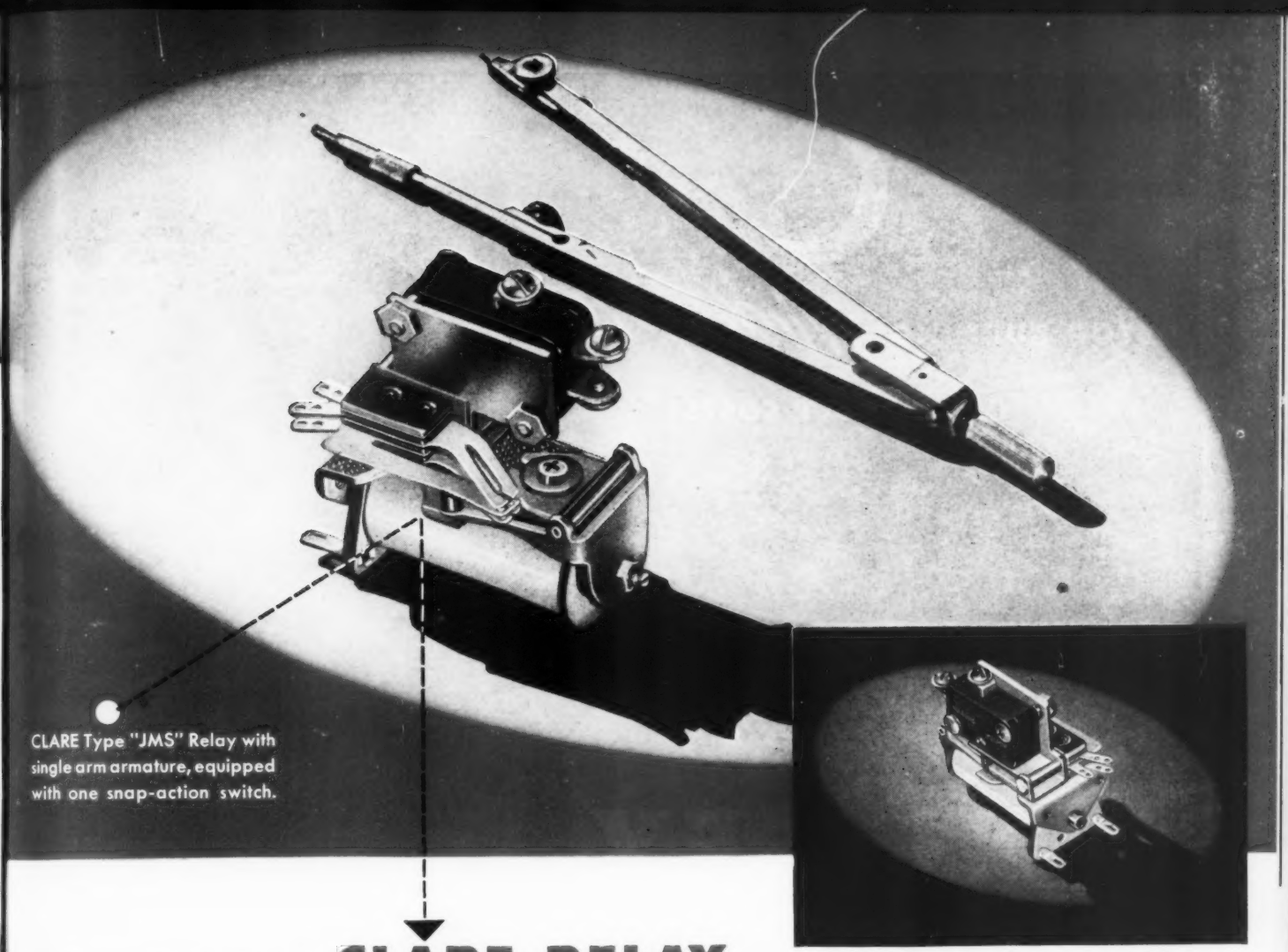
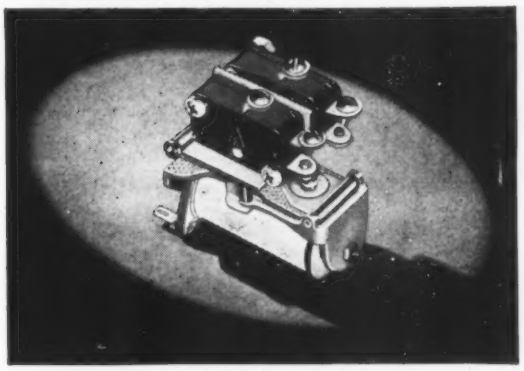


CLARE Type "JMS" Relay with single arm armature, equipped with one snap-action switch.

Showing mounting of snap-action switch on CLARE Type "JMS" Relay with single armature.



CLARE Type "JMS" Relay provided with double armature and two snap-action switches.

THIS SMALL, COMPACT CLARE RELAY

WILL SWITCH 1250 WATTS WITH AN INPUT OF 1 WATT!

This new CLARE Type "JMS" Relay is a sensitive relay for switching heavy a-c loads with small d-c controlling currents . . . as high as 1250 watts can be switched with a 1-watt input.

It combines the outstanding features of the larger CLARE Type "CMS" Relay with the small size and light weight of the CLARE Type "J" Relay and employs a new-type Micro precision switch of unusual efficiency and compact design.

The CLARE Type "JMS" Relay is especially suitable to locations subject to sudden jolts, constant vibration or tilting. It may be provided with either one or two Micro snap-action switches, or with one switch and a pileup of twin-contact springs. For installations where quick removal or replacement may be desirable, it may be fitted and wired to a standard radio type plug.

This new relay is a development of CLARE's unceasing effort to keep pace with every industrial relay requirement. Our engineers and sales representatives are constantly at your service to provide just the relay to meet your specific need.

For full information on the CLARE Type "JMS" Relay, look up the CLARE office in your classified telephone directory . . . or write for Bulletin 102 to C. P. Clare, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable Address CLARELAY.

STANDARD SPECIFICATIONS

Contacts: Snap-action, enclosed. Varying capacity: 10 amperes at 125 volts; 5 amperes at 250 volts.

Residual: Lock Screw (Adjustable).

Mounting: May be mounted on relay bases or strips as well as mounting bars or individual mounting brackets.

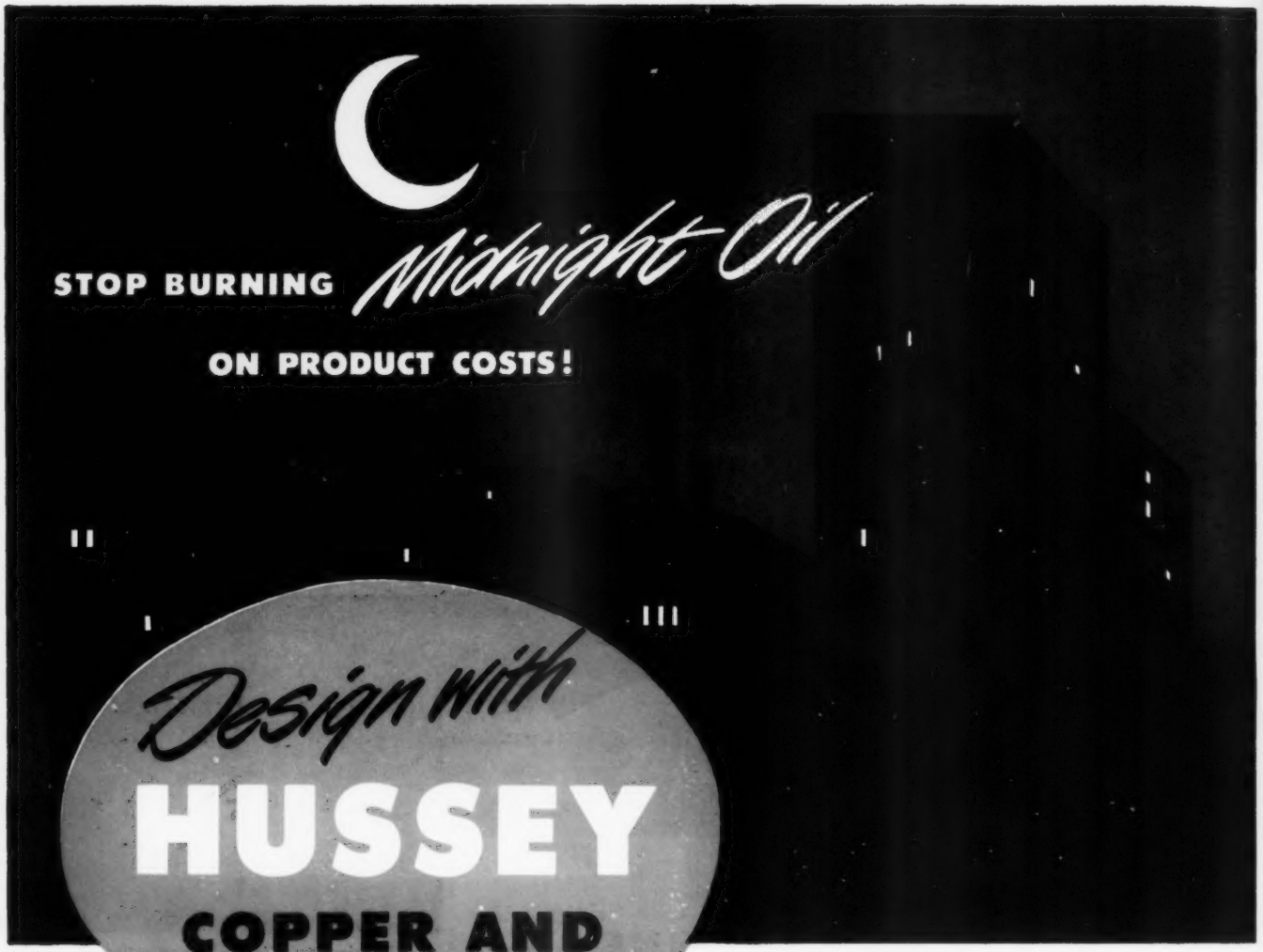
Dimensions: Overall length: 2¼"; width: 1⅛"; height: 2".

Weight: Net: 4 oz. (approx.); Shipping: ½ lb. (approx.)

Write for Clare BULLETIN 102

CLARE RELAYS

First in the Industrial Field



Designing to reduce product costs comes easy when you use the versatility of Hussey Copper and Brass. You can plan on easy forming or bending, speedy fabrication whether soldered, riveted or brazed, excellent heat or electrical conductivity, corrosion resistance, durability and lifetime beauty. Use these cost-cutting advantages of Hussey Copper or Brass to keep the fabricating costs down on your products. No other material can offer you so much extra value at so little extra cost.

SO MUCH MORE
Beauty Versatility Permanence
FOR SO LITTLE EXTRA COST

100 YEARS OF SERVICE
1848
1948
C.G. HUSSEY & COMPANY

C. G. HUSSEY & CO.
(Division of Copper Range Co.)
ROLLING MILLS AND GENERAL OFFICES
PITTSBURGH, PA.
Hussey warehouses carry stocks of Copper and Brass Products for prompt shipment.

Improved Efficiency in Plastic Molding Machines

Rockford's *Prize Winning Design* *uses a* LORD Vibration Control System

THE outstanding design features of the Rockford Hy-Jector Automatic Molding Machine won one of the five equal awards in an annual product design contest.

A Lord Vibration Control System is an important part of Rockford's design. Here's what Rockford says:

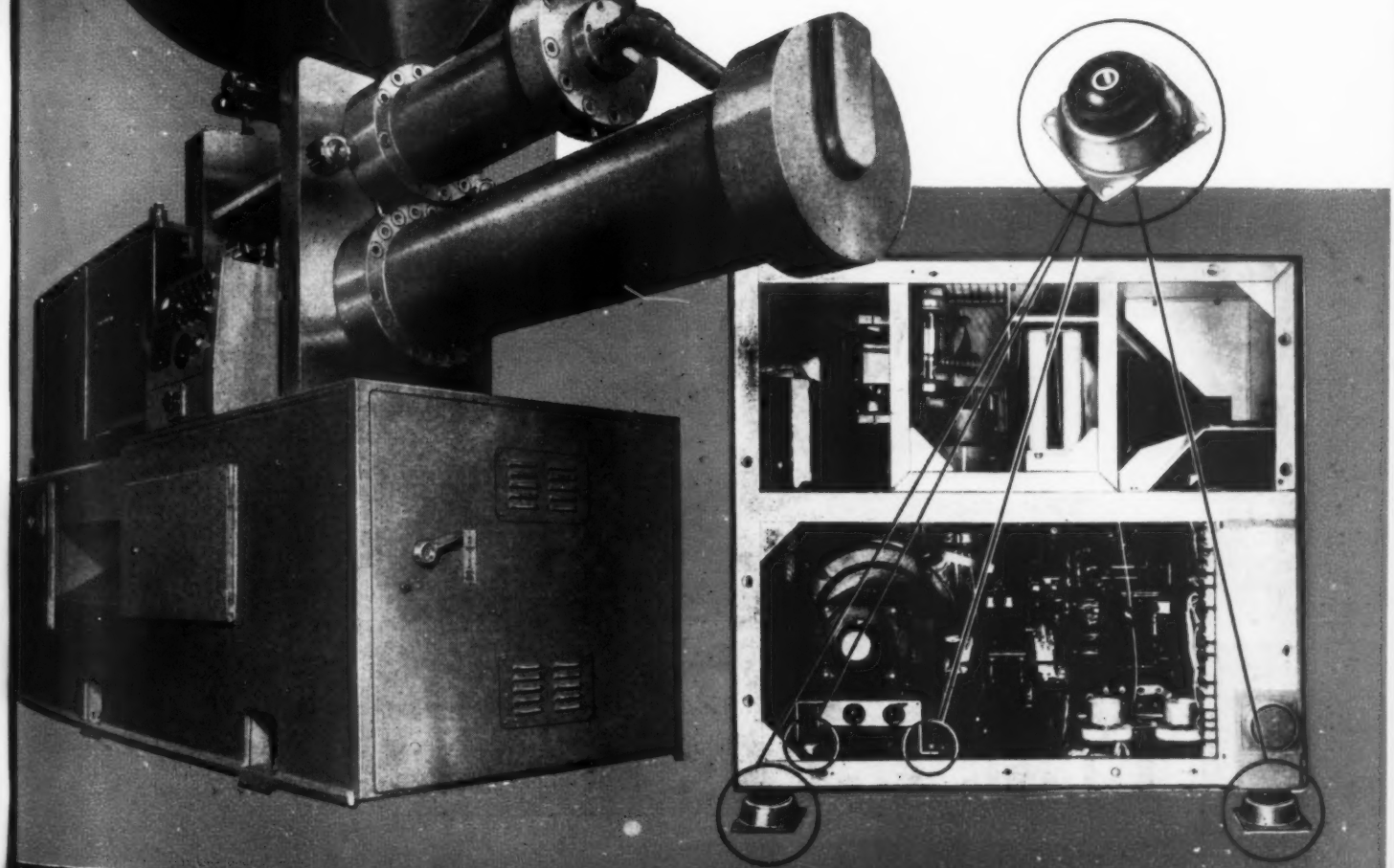
"In attempting to incorporate the maximum possible tube life and protection for the other components of the High Frequency R. F. Generator used in the Rockford Hy-Jector Automatic Molding Machine for Thermosetting Materials, we chose the Lord Mountings because of their superiority in the field of Vibration Control. They have proven themselves in our application."

This is another example of improved product performance with a Lord Vibration Control System.

Bulletin 900 is a complete outline of Lord products and services. Write for it today.

LORD MANUFACTURING CO., ERIE, PA.

Canadian Representative: Railway & Power Engineering Corp., Ltd.

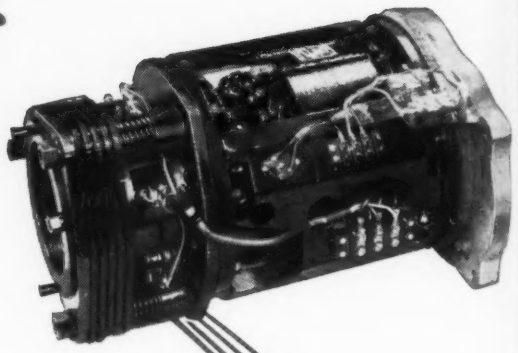


LORD Vibration Control Systems

The entire cabinet containing the dielectric heating unit is mounted on Lord Holder Type Plate Form Mountings, and the blower within the cabinet is separately mounted on smaller mountings of the same type.

FIBERGLAS*

...helps provide dependable finger-tip control



Moving tons of earth in a hurry is an easy job with LeTourneau Tournapulls. Easy —because they're operated by finger-tip control. Just a flick of a switch is all that is required to start electric motors that load, steer, turn and empty these giant earth movers. And *dependable* motors are highly important in this automatic operation because these machines work under the toughest weather conditions. That's why LeTourneau provides added protection by using motors insulated with Fiberglas-base Electrical Insulating Materials.

Other leading designers and engineers have found it's good insurance to have the added protection of Fiberglas-base Insulations. They've found, too, that these inorganic-base materials have helped solve problems such as the need for reduction in motor size, resistance to the effects of heat, overload, moisture, most corrosive acids and vapors, dust and many other causes of motor insulation failures. If you have a motor insulation problem, get more information about the advantages of these dependable materials by writing to Owens-Corning Fiberglas Corporation, Department 807, Toledo 1, Ohio, today for your copy of the "Fiberglas Electrical Insulating Materials" manual. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

LeTourneau Tournapulls, equipped with Fiberglas-insulated motors, generators and transformers, are manufactured by R. G. LeTourneau Inc., Peoria, Illinois.

OWENS-CORNING
FIBERGLAS
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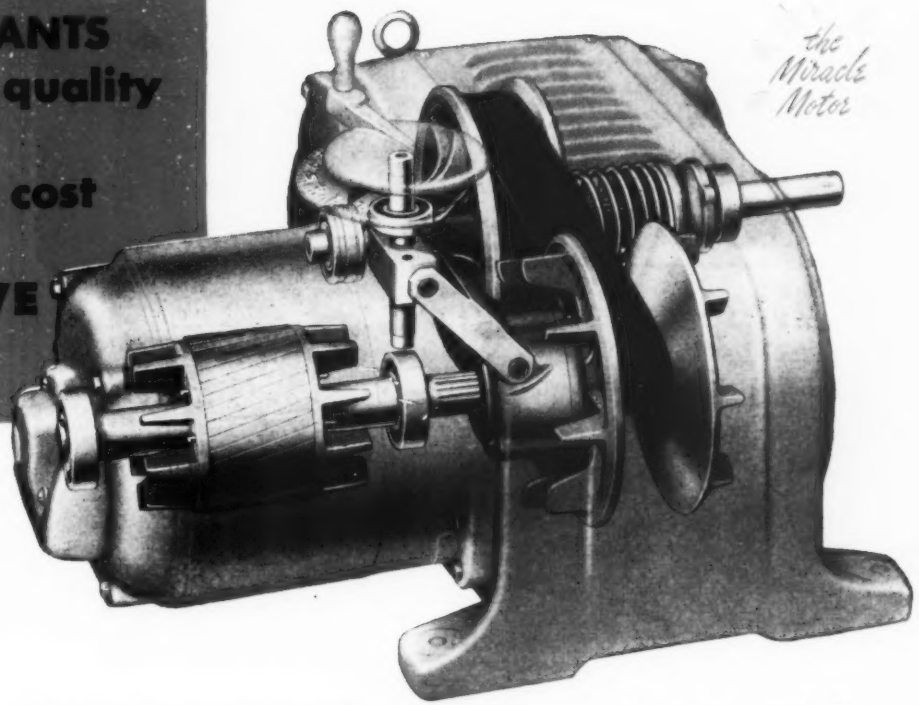
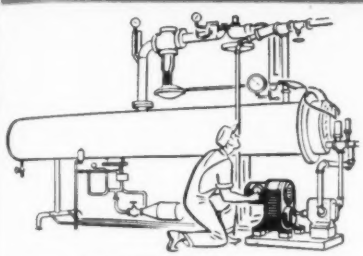
ELECTRICAL INSULATING MATERIALS

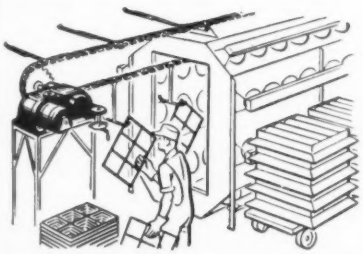
*Fiberglas is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

COUNTLESS PLANTS improve product quality and lower product cost with VARIDRIVE — like these

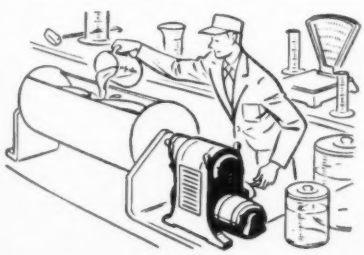




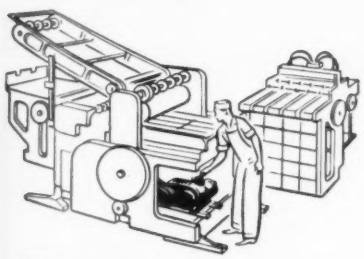
FOOD PROCESSING—Close control of heat, cold, pressure, humidity, evaporation, cooking, granulation, dehydration, homogenizing, etc., is best accomplished with Varidrive.



MATERIALS HANDLING — Variable speeds of conveyors, elevators, screws, chains, etc., permit materials to reach a destination in predetermined time.



BATCH MIXING — Ingredients, dry, fluid, viscous, powdered, granulated or in suspension, can be better blended by use of Varidrive to give correct speed for each mix.



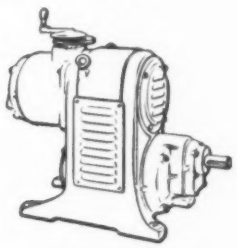
GRAPHIC ARTS—Various types of machines in printing plants are operated by Varidrive to obtain speeds best suited to each job.

You get more machine output too, with *U. S. VARIDRIVE MOTORS*

Fixed motor speed places a limit on the production capabilities of machines. By installing Varidrive you increase each machine's productivity from 10 to 30 per cent, or more, because speeds can be infinitely varied to meet changing conditions. Not too fast, not too slow, but just the right speed for each and every operation means better quality, maximum output—therefore lowest-cost per unit.

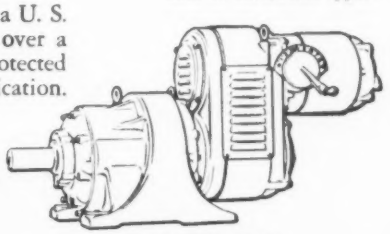
The U. S. Varidrive Motor combines in one simple, compact unit the mechanism to instantly change speeds of the driven machine without resorting to the use of cumbersome and complicated devices. Speed of the rotor is constant. Speed of the take-off shaft is any rpm desired. Whatever speed you select can be maintained without fluctuation. The initial cost of this miracle motor will be returned again and again by reducing costs of production.

Dependable operation is assured when you install a U. S. Varidrive. Its design has been perfected and tested over a period of 15 years. U. S. Motors embody asbestos-protected windings, normalized castings and lubriflush lubrication.



UPRIGHT MODEL
Shaft can be set high or low, control handle changeable from top to either side. Also available in horizontal type.

1 to 10,000 RPM
¼ to 50 H.P.



COMBINATION VARIDRIVE—SYNCROGEAR
Requirements for slow speed with instantly variable characteristics are best powered by this type Varidrive-Syncrogear unit. Double or triple reductions are available.

A Tip to the very wise Buy VARIDRIVES

Learn how
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A new, fact-filled 16-page Bulletin, in color, describing Varidrive is available. A diaphanous view and interesting illustrations portray the operating mechanism. Ways to cut production costs and operator's fatigue are presented.

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Production savings and sales advantages result from redesign with four Truarc rings

- Eliminate two drilling, two tapping operations, and the fabrication of two collars and four pins.
- Eliminate two set screws.
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- Make for closer tolerances.
- Make drive shaft self-aligning: operation by user greatly simplified.
- Make more delicate adjustments easier for user.
- Streamline entire unit.
- TOTAL OVERALL SAVINGS, per unit . . . $1.00

Elevator-rod detail of Skyview Condenser Enlarger, where Truarc Inverted Retaining Rings provide uniform shoulder for abutting curved surface of helical spring, improve product.

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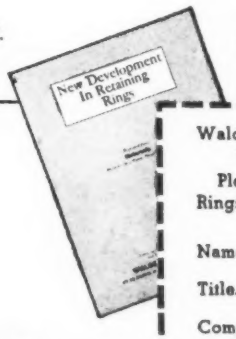

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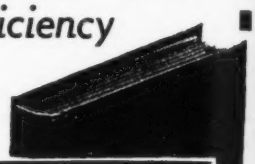

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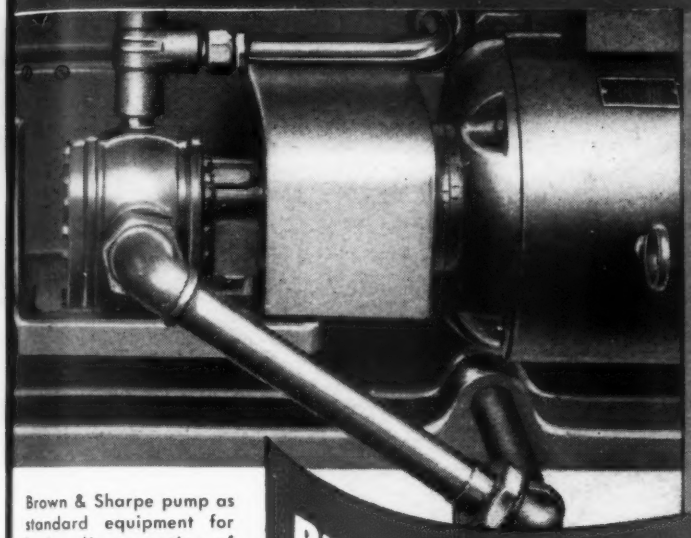
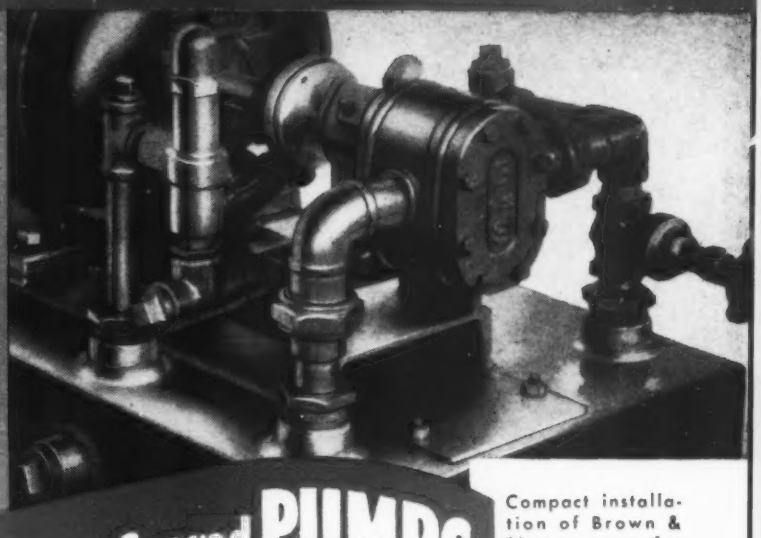
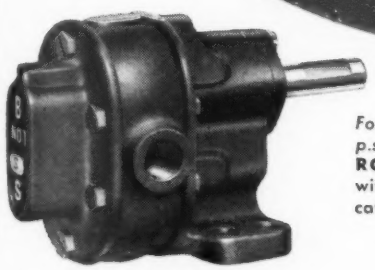


Brown & Sharpe pump as standard equipment for hydraulic operation of machine tool.



Compact installation of Brown & Sharpe pump for hydraulic operation of stoker unit.

BROWN & SHARPE Rotary Geared PUMPS



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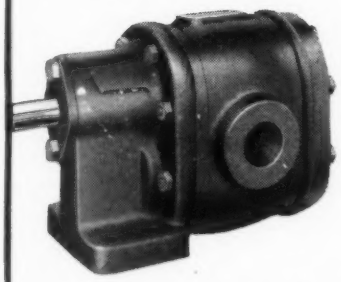
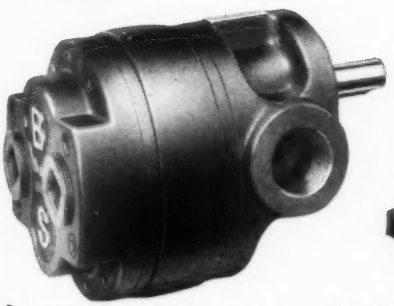
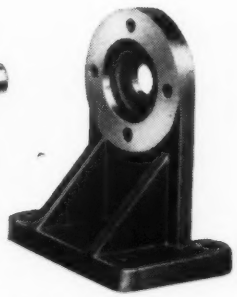


For pressures up to 200 lbs. p.s.i. . . . **NOS. 53 and 55 ROTARY GEARED PUMPS** with roller bearings and helical gears.





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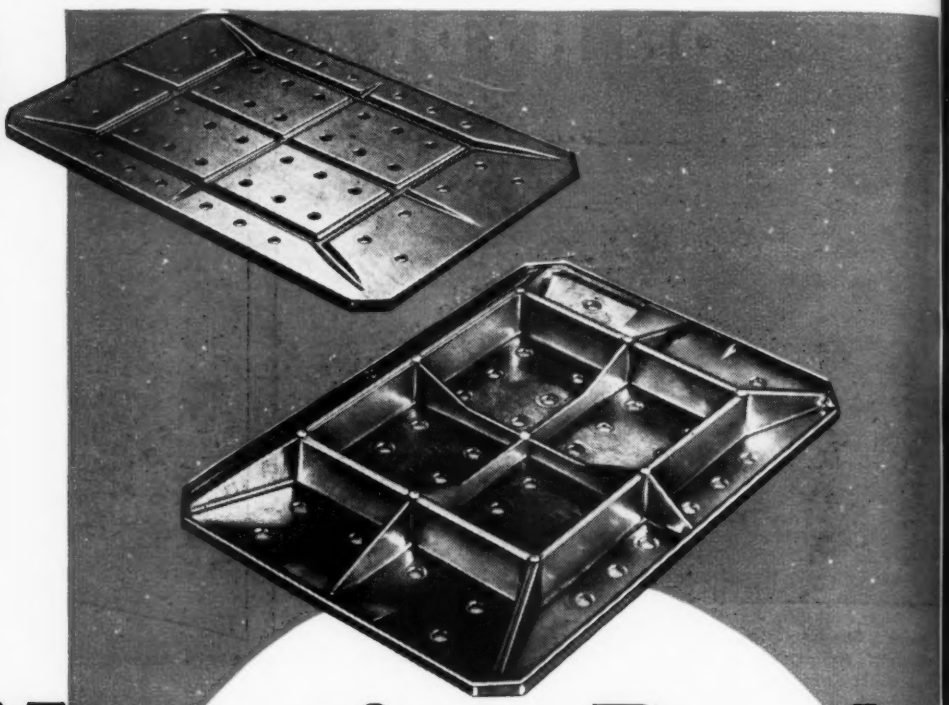

How Magnesium Pays!

IN MANUALLY HANDLED EQUIPMENT

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Bottom boards, well-known to the foundrymen, are traditionally made of wood. They present a problem to sand foundries because of their tendency to burn, warp, split, become loose and cause mold "shifts", "breaks" or "cracks". One progressive manufacturer decided to attempt a design in a material that would eliminate these problems common to wood bottom boards.

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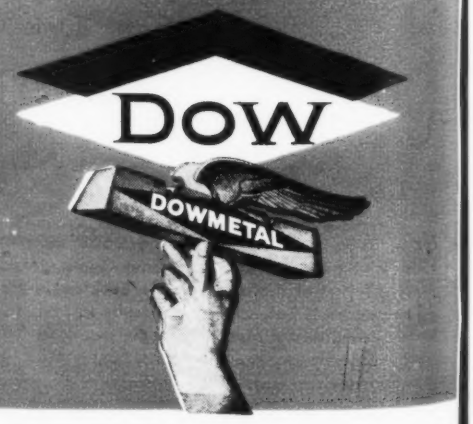

"Tubing?...Yes, I know where we can get it

"In *our* business we can't afford to get caught short. Constant market changes, unstable conditions, and our large volume requirements compel us to keep tab on a lot of suppliers—both actual and potential.

"So when the Chief asked about tubing, I was able to pop right back, 'Sure, I know where we can get it.' I knew that we could send steel to Nikoh and get quick service on the big quantities of tubing we need."

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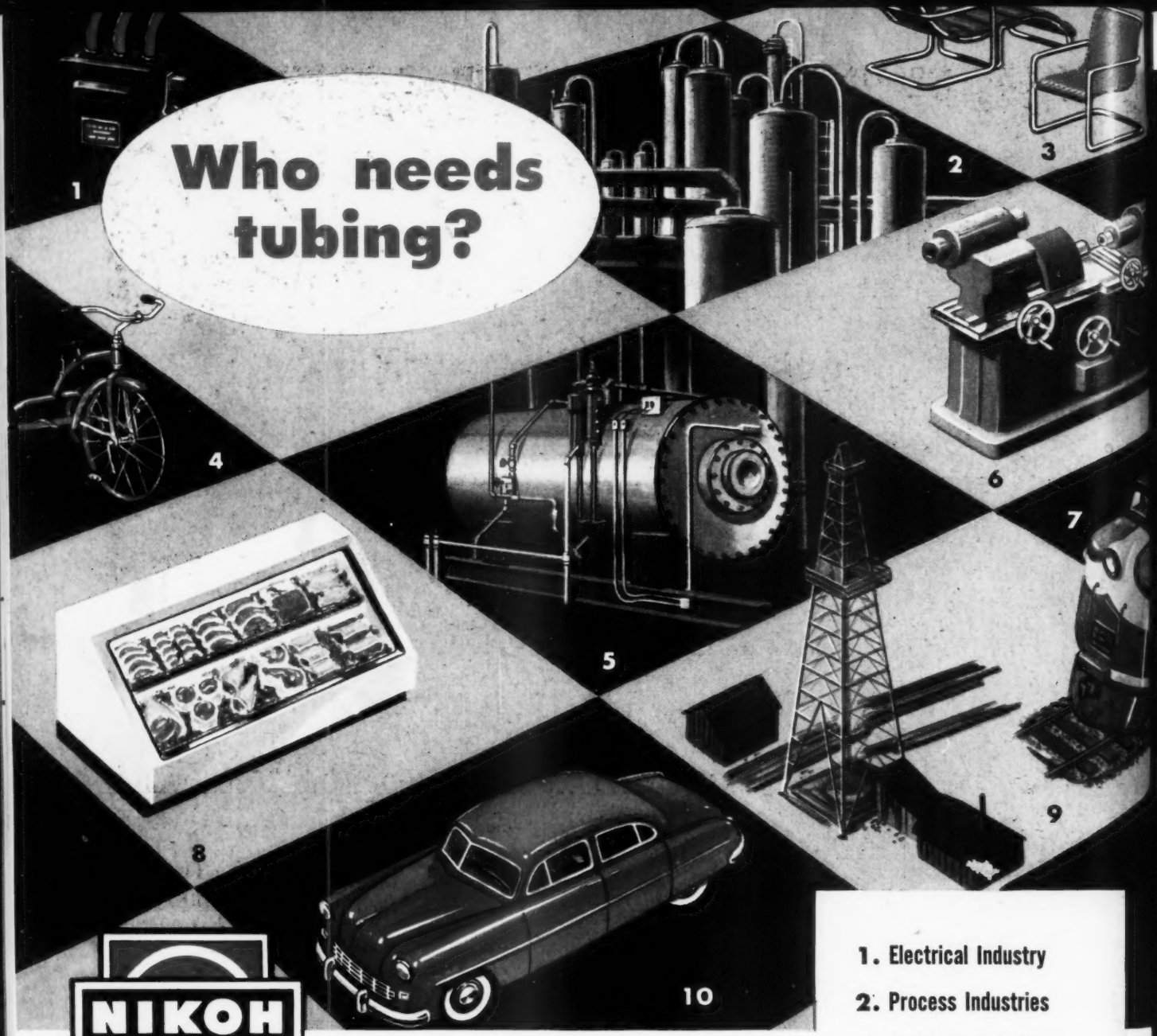

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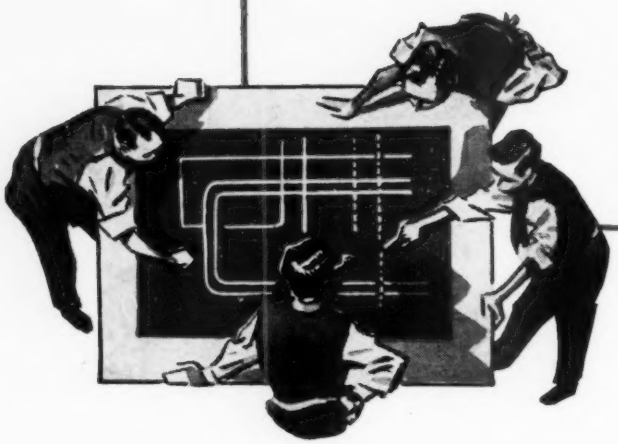

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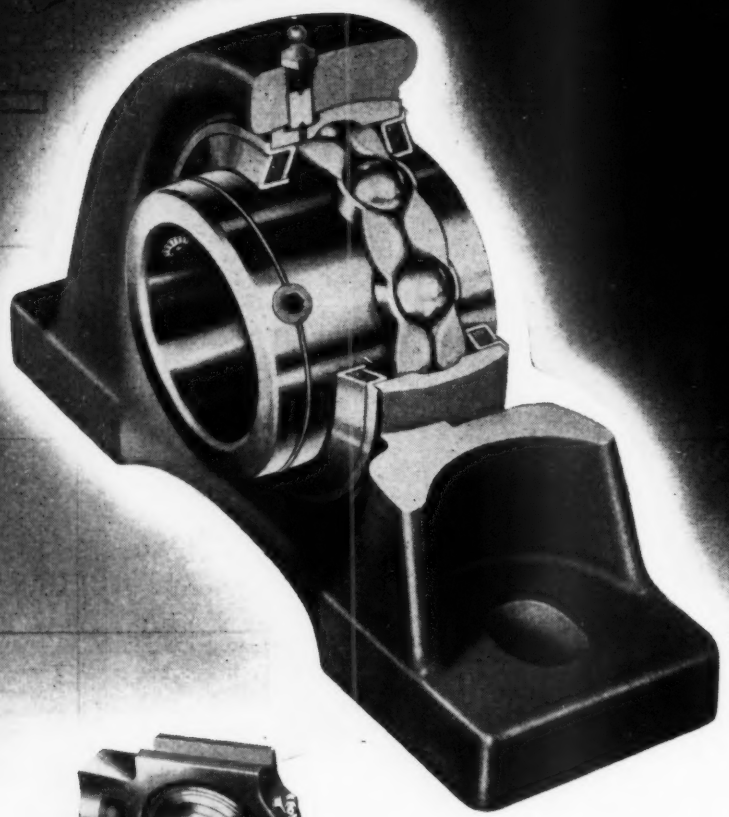
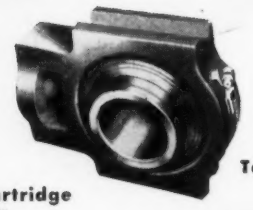
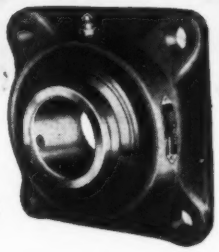


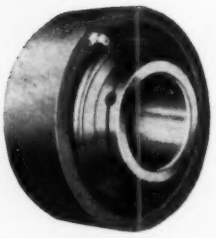


Take-up Unit



Flange Unit

Flange Cartridge Unit



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Photomicrographs give important data to Scaife engineers and production men regarding the behavior of alloy steels under various conditions.

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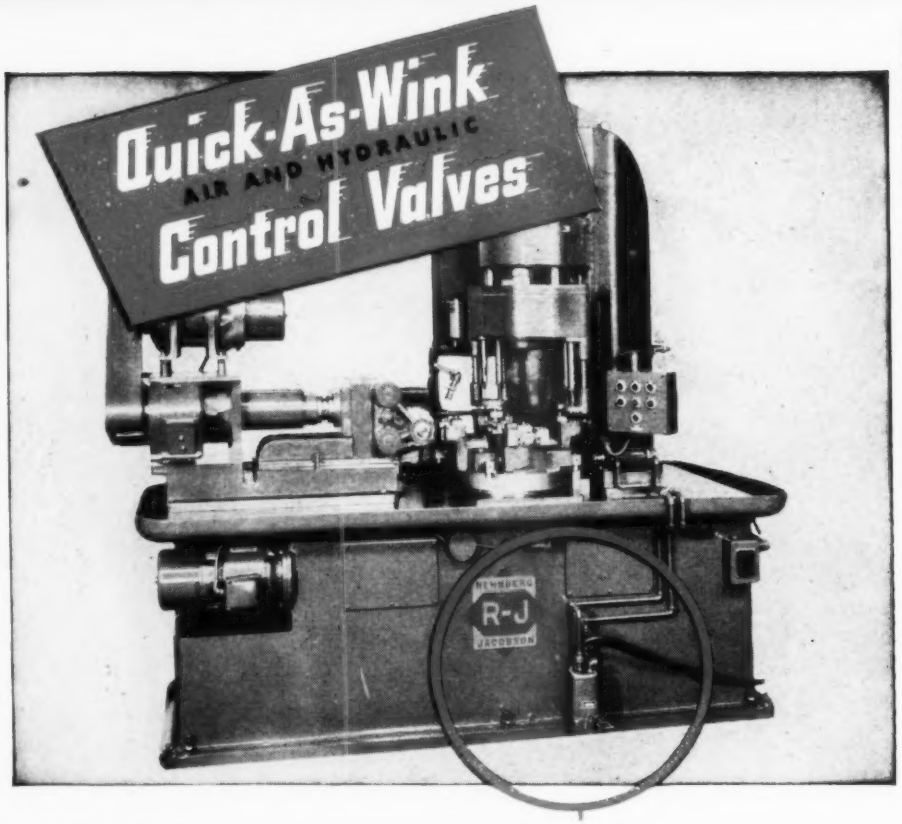

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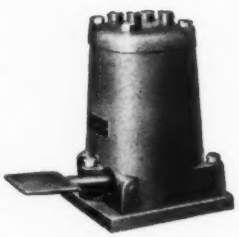

Quick-As-Wink Foot Operated Air Valves

The 3401-RA4 pictured above is a 4-way two position valve for controlling double acting air cylinders. Ideally used with brakes, shears, presses, forging machines, etc., because the operator has both hands free to handle the work. Furnished in 3/8", 1/2", 3/4", 1", 1 1/4" and 1 1/2" sizes. 3-way and 4-way neutral position or regular actions—for air up to 125 lbs. pressure and 150° F.;—but send for a catalog today and get *full* details about the *complete* line.

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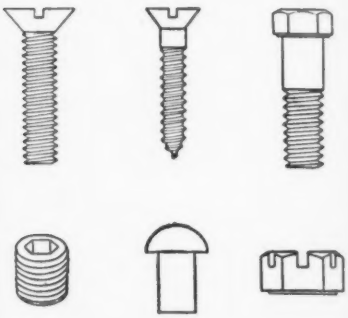

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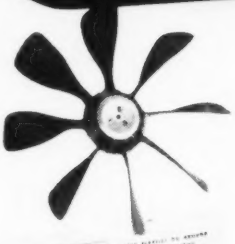

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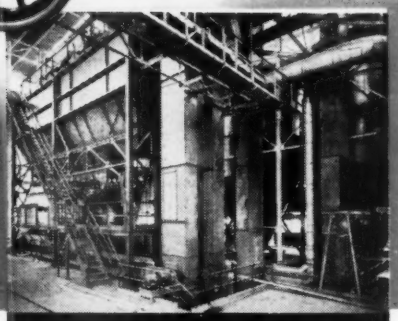

Unitcast's continuous Sand Mill that processes an average of 750 tons of molding sand per day.

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For example, at Unitcast, operation of the "Sand Control" system is just *one* of many comprehensive details that only reflects in the quality of the product. During each operating hour, constant vigilance and continual testing is necessary to control the many, many elements that mix good molding sand. Such items as moisture, permeability and the like *must* be held within definite limitations to produce Unitcastings efficiently. Differences in design between incoming and outgoing jobs on the molding line upset the immediate standards and the unusual jobs require special mixtures.

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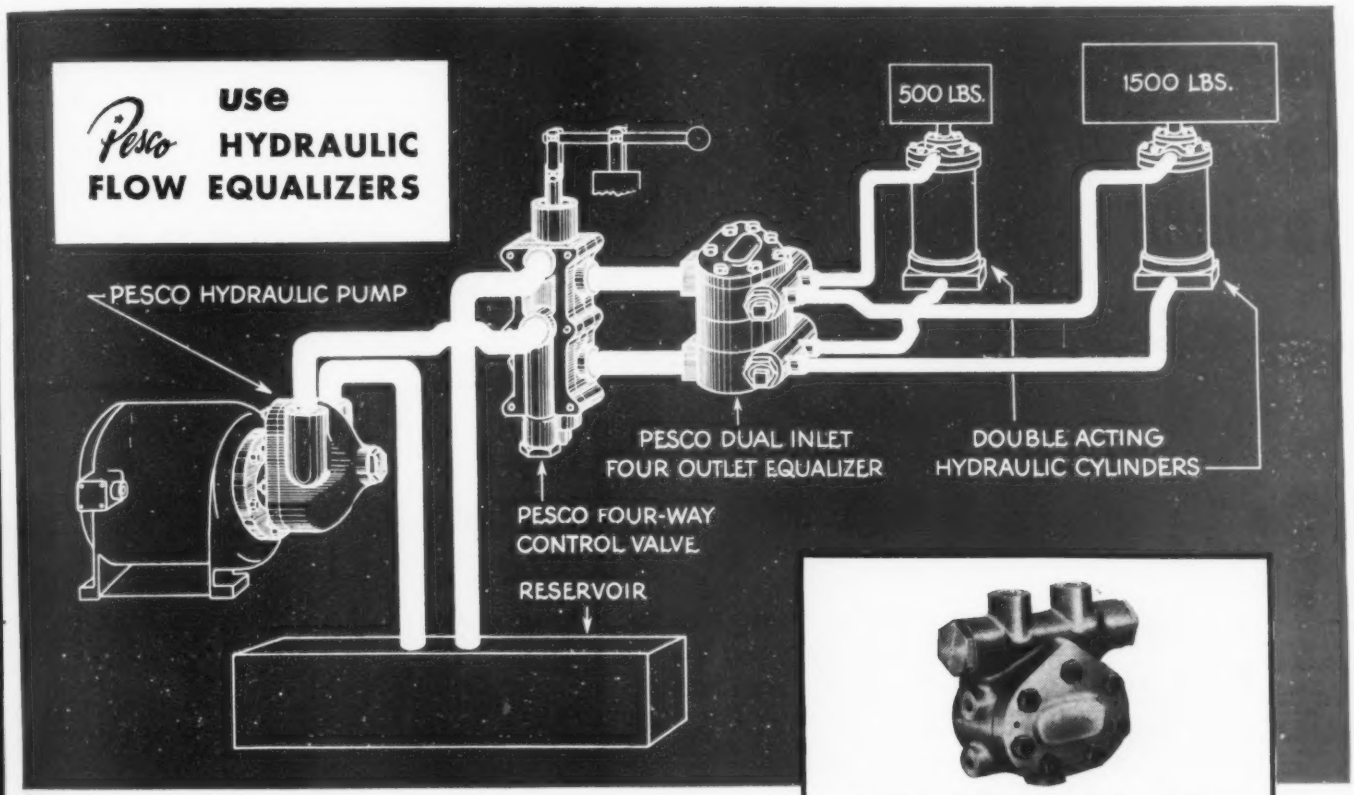
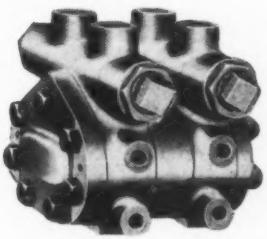


Equalizer with single inlet and two outlets . . . controls stroke in one direction for two single-acting cylinders.



Equalizer with two inlets and four outlets . . . controls the flow to two double-acting cylinders. In another version this model can be furnished with a single inlet and four outlets for controlling the flow to four single-acting cylinders.

Whenever equipment must be designed to move unequal loads forward and backward, or up and down in precisely equal movements, it will pay to study the advantages of Pesco Hydraulic Flow Equalizers.

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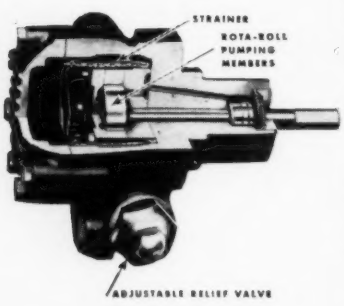
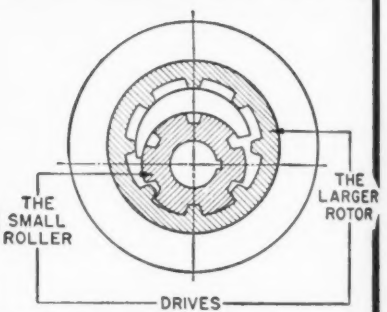
Available in 5 Sizes, From 6 G.P.H. to 35 G.P.H. This pump has an adjustable relief valve for settings up to 300 PSI. The five sizes range from 6 G.P.H. to 35 G.P.H. These figures are based on a motor speed of 1725 RPM and 100 PSI.



Small, Compact and Quiet in Operation

You'll like the quiet performance of this pump, and you'll like the ease with which it can be adapted to your design. It's small, compact, and will improve the appearance of your product.

Rota-Roll Principle Offers 6 Advantages



1. ROTA-ROLL PRINCIPLE of pumping members promotes quiet operation, longer life because (see above) smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.
2. QUIET OPERATION because ROTA-ROLL pumping members and efficient inlet port design reduces cavitation at the inlet port.
3. SMOOTH UNIFORM FLOW AT ALL PRESSURES because rotating roller and rotor are self-emptying, eliminating turbulence, and other interference with smooth uniform flow of oil.
4. SMALL AND COMPACT (see illustration) will lend itself to and improve your product appearance.
5. HIGH OVERALL EFFICIENCY at maximum continuous duty pressure.
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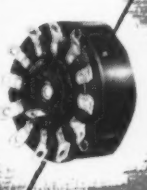

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Years of experience in building dependable rheostats and resistors, in helping others solve specialized resistance problems, is your assurance that Ohmite "Know-How" can help you. We invite you to submit your problems to us.

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Close Control
RHEOSTATS

. . . Available with many additional features

On this page are shown some of the many forms in which standard Ohmite rheostats can be furnished. All models have the distinctive, time-proved features of Ohmite design. They are all-ceramic in construction—ceramic parts insulate the shaft and mounting, and the resistance winding is permanently locked in place by vitreous enamel. Smoothly-gliding, metal-graphite brush provides contact with every turn of the resistance winding. Ohmite rheostats are known for their smooth, gradual, close control and their long, trouble-free life.

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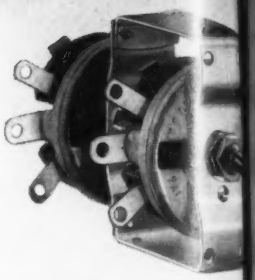
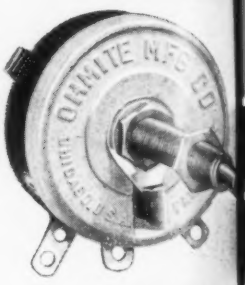
Ohmite rheostats can be mounted with two, three, or more in tandem, for simultaneous operation of several circuits by one knob.



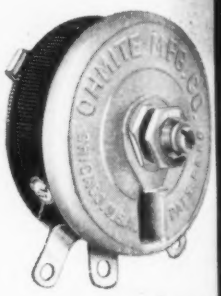
with BUSHINGS for special panel thickness

Rheostats can be furnished with extra-long bushings and shafts for panels over ¼" and up to 2" in thickness. Five bushing lengths.



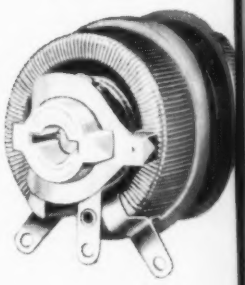
with SCREW DRIVER SLOT SHAFT

Shaft ends can be slotted for operation with a screwdriver, where few adjustments are needed. Minimizes tampering with setting.



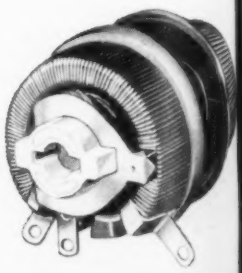
with DEAD LUG OFF-POSITION

Opens the circuit at the high resistance position as the contact passes on to the lug, which is disconnected from the winding.



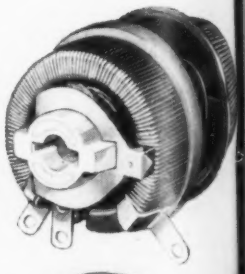
with SNAP-ACTION OFF POSITION

Opens the circuit at the high or low resistance position. The contact brush snaps into an insulated notch next to the lug, providing indexing.



with DEAD-SECTION OFF POSITION

Opens the circuit at the high or low resistance position as the brush passes off the lug onto an insulated section. Medium duty.

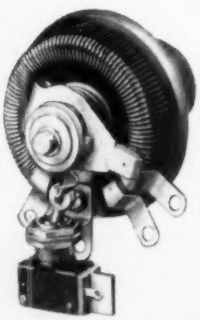


in TABLE MOUNTING CAGES

Used to prevent mechanical injury to the rheostat or human contact with electrically "live" parts. Tabletop mounting, ventilated enclosures.

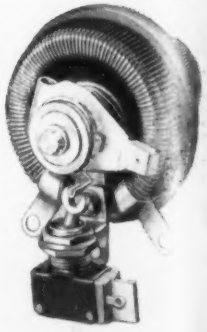
with TOGGLE SWITCH and EXTRA LUG

Permits dual switching of rheostat and independent circuits. Rheostat winding is terminated at an extra lug located where the switch opens.



with TOGGLE SWITCH

Toggle switch is operated with a positive snap by the rheostat arm at either end position. Used for heavy duty applications.



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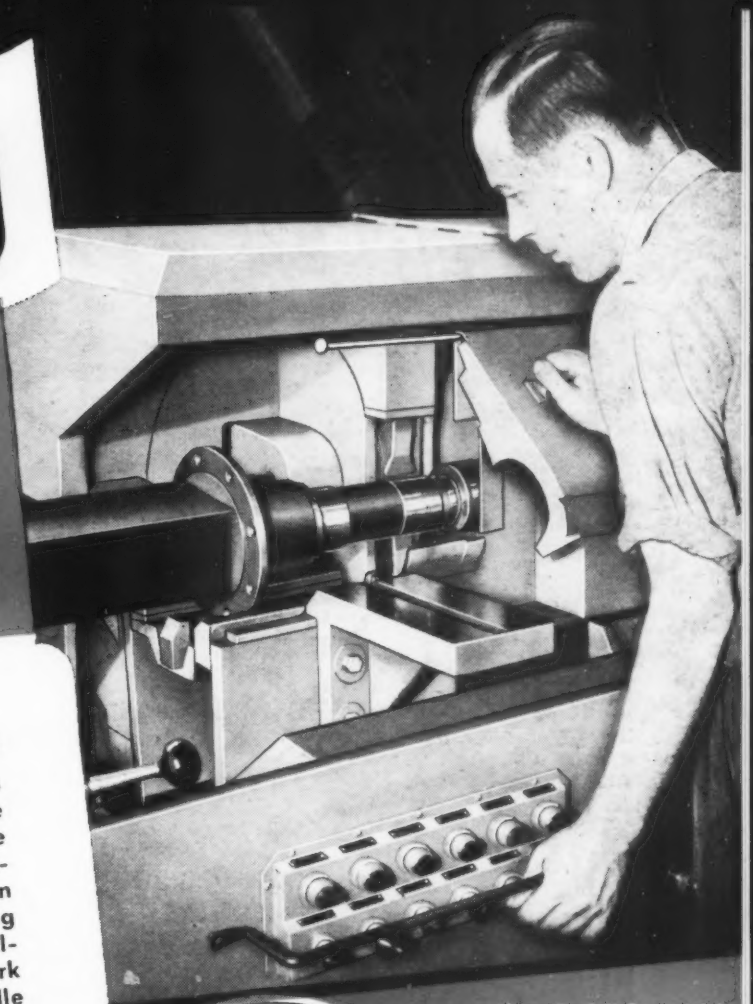

For Instance,

On Applications of Modern Thread Grinding:

The special Ex-Cell-O machine illustrated here grinds threads on large tough axle housings for some of the heaviest trucks and busses that travel the highways. The housings are made of forged steel hardened to approximately 40-C Rockwell. Special tooling on this production machine includes approximate locators to aid in handling the heavy awkward parts, a hydraulically actuated tailstock which shifts the parts from the locators to the work centers, and an automatic chuck on the work spindle which eliminates the need for a driving dog. The wide multi-rib grinding wheel cuts the threads fast. A combination of electric and hydraulic actuation and controls simplifies operation of the big grinder.

If you have any production work or problems that involve thread grinding, get in touch with your nearest Ex-Cell-O representative or write to Ex-Cell-O Corporation, Detroit.

Above: Ex-Cell-O special thre grinder at work on axle housing.

Center: A close-up view of end of an axle housing sha ing the ground thread.

Below: Special Ex-Cell-O Thr Grinder for grinding threads heavy forged steel axle ho ings. Note the clean sim lines of the welded steel b and the convenient group of operating controls.

EX-CELL-O CORPORATION

Detroit 32, Michigan

Special Multiple Way-Type Precision Boring Machines • Special Multiple Precision Drilling Machines • Precision Boring, Turning, and Facing Machines and Fixtures
Precision Cylinder Boring Machines • Precision Thread Grinding Machines • Precision Lapping Machines • Precision Broach Sharpening Machines
Other Special Purpose Machines • Tool Grinders • Continental Cutting Tools • Broaches and Broach Fixtures • Counterbore Sets • Grinding Spindles
Hydraulic Power Units • Drill Jig Bushings • R.R. Pins and Bushings • Fuel Injection Equipment • Dairy Equipment • Aircraft and Miscellaneous Production Parts

IT TAKES AN AHLBERG BEARING TO...

RUN RINGS AROUND FRICTION!

Anti-friction minded? Of course you are. But are you using bearings that really conquer, really **RUN RINGS AROUND FRICTION?**

Making truly superior ball bearings isn't simply a matter of "marrying" good races to good balls and good retainers. What counts is how well these basic components are **mated**—how well they are designed and engineered to "get along with each other" as life-time team mates.

Micro-analyze any Ahlberg ball bearing and you will find . . . balls that are accurate to .000025" in sphericity, matched in sets to .000025" . . "generated" raceways that assure true race curvature, perfectly matched ball paths . . . chrome alloy electric furnace steel that is meticulously heat-treated for maximum toughness without brittleness.

In all other ways, from blue print inception to final inspection, Ahlberg bearings are . .

PRECISION MADE—PRECISION MATED.
Sales engineers and branches in principal cities.

AHLBERG BEARING COMPANY
3019 W. 47th Street • Chicago 32, Illinois

AHLBERG Bearings
CHICAGO
BALL BEARINGS • ROLLER BEARINGS • PILLOW BLOCKS

1
2
3
4
5
Data on Formica
Can you identify these parts?
The book "Data on Formica" gives full information on how Formica Parts contribute to the smooth operation of thousands of consumer and industrial products. Examples: 1 Ball Bearing Separators. 2 Motor Control Switch Insulation. 3 Factory truck wheels. 4 Electrical Contact Spacers used in Calculating Machines. 5 Distributor Timing Plates for Aircraft Magneto. "Data on Formica" outlines our custom manufacturing service, demonstrates how Formica's physical properties are tailored to your specifications. Write for your copy, together with typical sample parts. FORMICA, 4676 Spring Grove Ave., Cin'ti 32, O.
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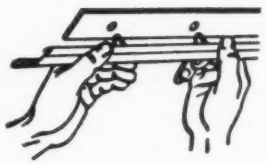
Productive
FORMICA
at Work in Industry



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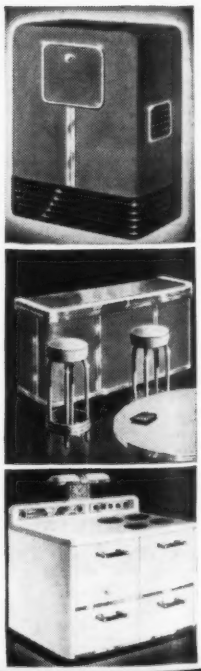
Snap-Clip
ALL IT NEEDS IS A HOLE!

DRESS UP YOUR PRODUCT..

SPEEDILY . . ECONOMICALLY



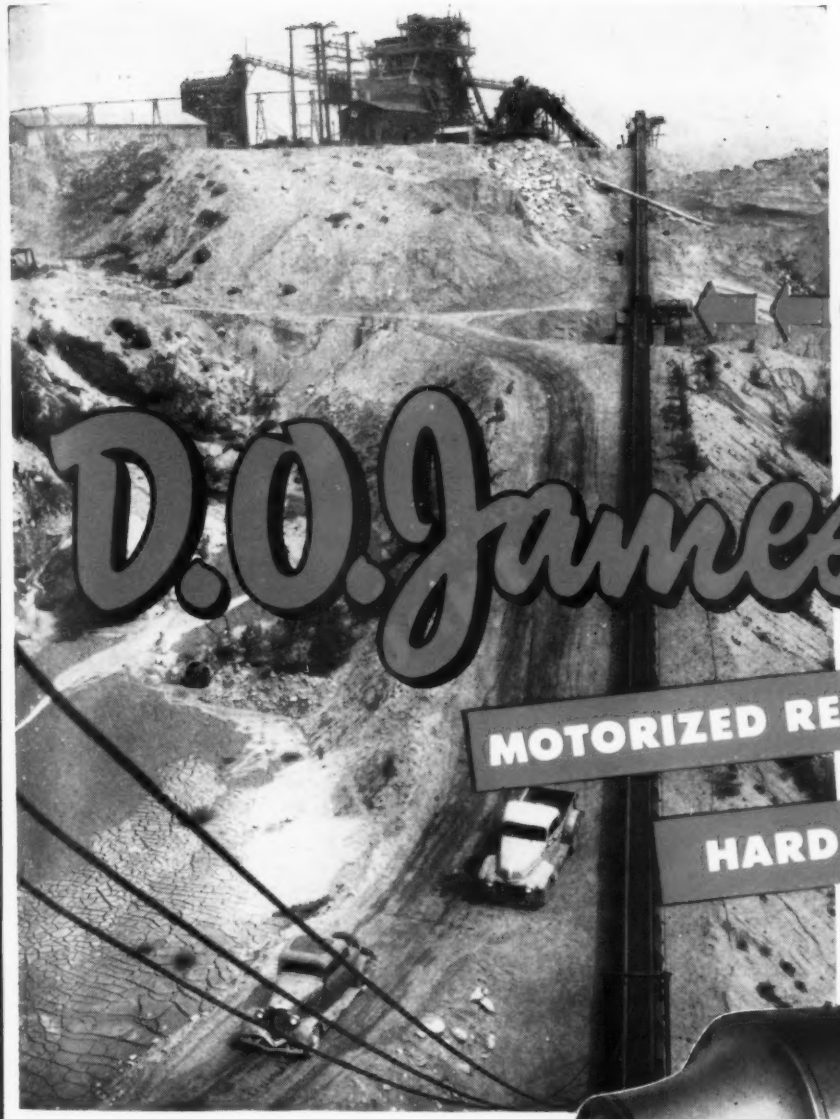
IN ADDITION TO EYE APPEAL SO vital to sales and profits, Snap Clips provide a low cost, simple, speedy and effective method of applying trim or moulding to your product.

A slight pressure of the hands does the job in a jiffy . . . the Snap Clip alone does the entire job of holding . . . all it needs is a hole.

If you have a fastening or joining problem we'll gladly advise you about the Snap Clip application to your products.

A SUBSIDIARY OF Barium STEEL CORPORATION

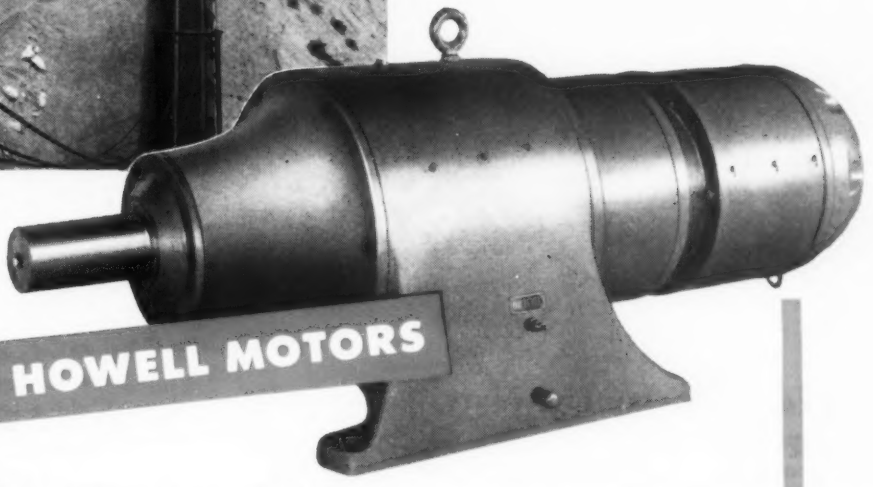
The CUYAHOGA SPRING *Co.*
10251 Berea Road • Cleveland 2, Ohio



D.O.James Motorized Reducer, size 202M, 60 horsepower, 90 R.P.M.—using Howell totally enclosed fan cooled motor—driving large belt conveyor.

D.O.James

MOTORIZED REDUCERS MAKE THE HARD JOBS EASY!



WITH HOWELL MOTORS

D.O.James Motorized Reducer, the centrally balanced drive with great emergency strength, is an important factor in this rock moving job. The conveyor belt, driven 350 feet per minute, moves 550 tons of rock an hour—*really making the hard jobs easy.*

This simplified assembly, using Howell standard flange type motors, coupling connected with high speed pinion gear shaft makes for greater accessibility.

Howell Precision-Built Motors are the product of Howell Electric Motors Company, Howell, Michigan—Makers of Quality Motors Since 1915.

D.O.JAMES GEAR MANUFACTURING COMPANY

Since 1888—Cut Gears • Gear Reducers • Flexible Couplings

1140 W. Monroe Street • Chicago, U. S. A.

Each Rollway Bearing takes only its specific load . . . The radial bearing takes radial loads; the thrust bearing takes thrust loads. In this simple but effective way, Rollway's Right Angle Loading eliminates compound loads and complicated stresses. Specifically, it splits your load in two.

Rollway Right–Angle–Loading helps your machines to run longer . . . under heavier loads . . . with lower maintenance cost

It reduces the unit loading on rollers and bearings. Insures lower starting and running torque. Eliminates all resultants from oblique loads, all piling up of thrust and radial loads on the same bearings. Reduces roller end-rub and roller wear-back . . . avoids roller pinch-out . . . provides greater resistance to shock.

Lower maintenance!
Fewer shut-downs!
Less replacements!

FREE SERVICE

Send us your designs for bearing analysis and recommendations. All information held confidential.

ROLLWAY BEARING CO. INC.
Syracuse, N. Y.

ROLLWAY
RIGHT-ANGLE-LOADED
BEARINGS

OFFICES IN: PHILADELPHIA • BOSTON • PITTSBURGH • CLEVELAND • DETROIT
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NEW
PRODUCT IDEAS
WITH
CELLULOSIC PLASTICS

ACETATE ADDS UP TO "SALES"

FOR BUSINESS
MACHINE
MANUFACTURERS

Suggested design for desk calculator by Carl Sundberg, Sundberg & Ferar, Detroit, Mich.

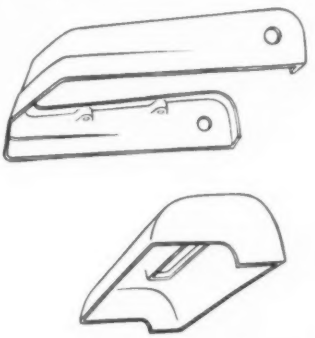
This design for a calculator housing is an excellent example of the many product advantages afforded by versatile cellulose acetate.

Shatterproof, resilient, lightweight, with a permanently lustrous finish, acetate is the ideal plastic for products that are subjected to day-in-day-out use. Dimensionally stable, it may be molded to close tolerances—permitting secure and rapid assembly with integral metal sections. New formulations even provide flame resistance.

Perhaps low-cost cellulose acetate housings or parts can add new durability and sales appeal to your product. Our technical service staff invites your inquiries.

HERCULES POWDER COMPANY
904 Market Street, Wilmington 99, Delaware

Sectional view showing easily assembled two-piece housing. Keys and knobs are molded as separate units.



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Dimensional Stability · Permanent Color & Finish
Thin-walled Toughness · Rapid, Secure Assembly
Lightweight

SUPPLIERS OF HIGH-QUALITY CELLULOSE DERIVATIVES FOR PLASTICS

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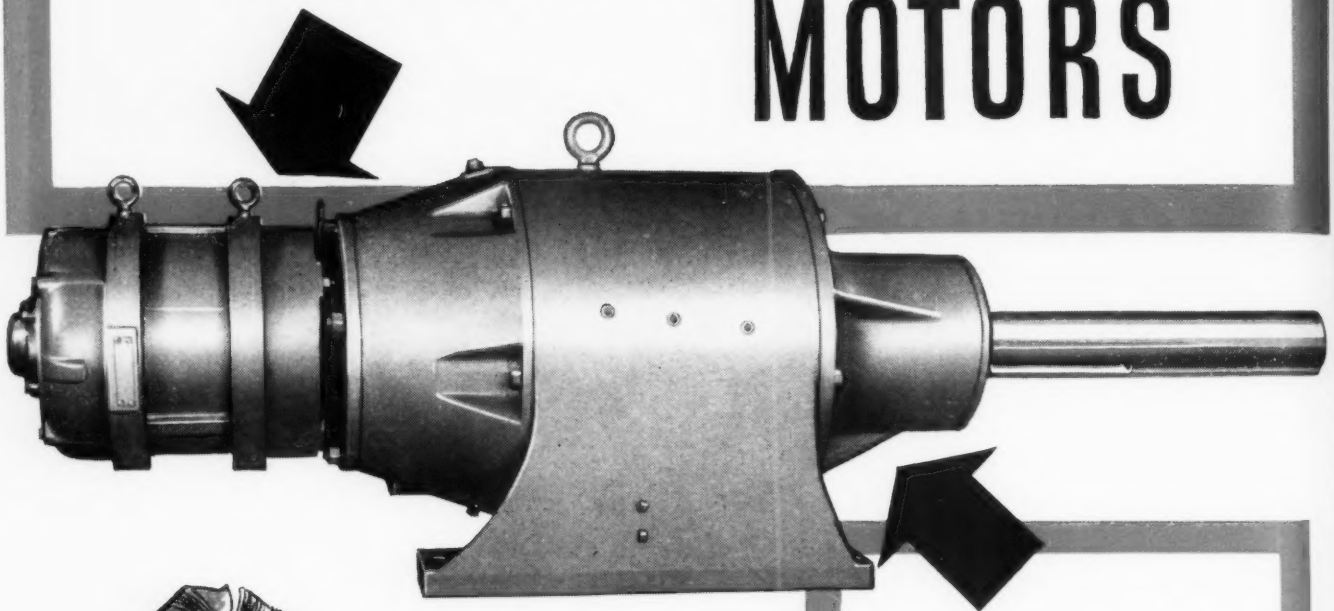
CELLULOSE ACETATE · ETHYL CELLULOSE · NITROCELLULOSE

HOWELL *industrial type* MOTORS



Here's a reliable gear-motor combination you'll want to look into.

D. O. JAMES GEAR REDUCER

Why?

Because the motor is an industrial type motor built by Howell and backed by 33 years' experience in building industrial type motors exclusively.

The gear reducer is built by the D. O. James Manufacturing Company, specialists in their field with more than 50 years' experience.

The combination makes an integral packaged unit with the motor flange-mounted to the reducer, yet with a flexible coupling so that motor and reducer can readily be separated for maintenance.

For a modern, economical means of obtaining relatively low speeds from constant speed motors in your business, be sure—buy Howell!

RED BAND MOTORS
HOWELL
SINCE 1915

For geared motors, motors with unique electrical characteristics, special mechanical form, or standard motors (with any type of enclosure) from 1/6 through 150 HP, consult your HOWELL representative.

HOWELL ELECTRIC MOTORS CO., HOWELL, MICHIGAN

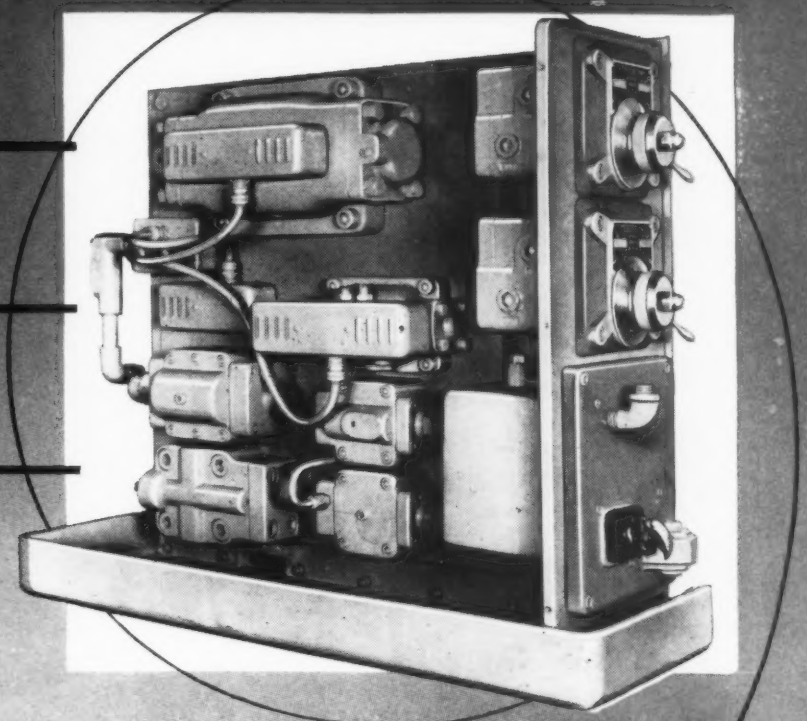
MANUFACTURERS OF PRECISION BUILT, INDUSTRIAL TYPE MOTORS

VICKERS Gasket Mounted Hydraulic CONTROL VALVES

Simplify Installation

Save Space

Make Adjustment Easier



This new Colonial Pull-Down Broaching Machine is an excellent example of how Vickers Gasket Mounted Valves simplify installation, save space and make adjustment easier for hydraulic control systems.

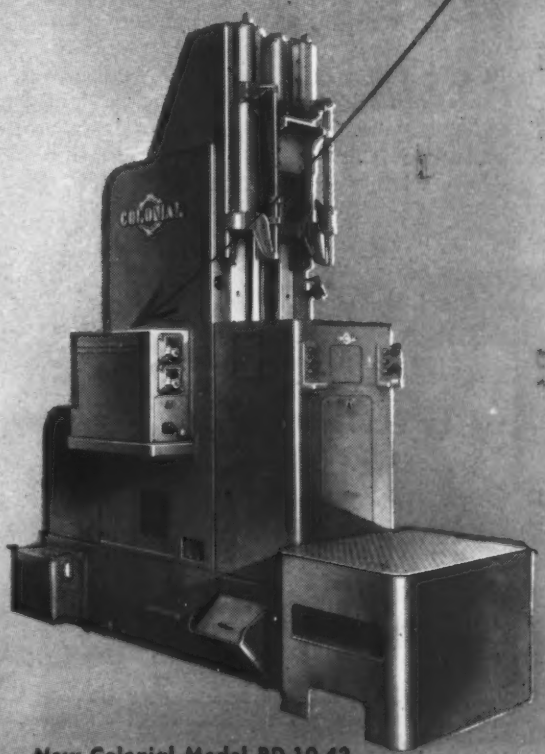
All valves in the panel box are easily accessible for adjustment by simply removing the cover. For cleaning and other maintenance, any valve can be completely removed by just loosening the hold-down screws . . . the piping is not disturbed and the system is not drained. The installation is simplified and more compact because all hydraulic piping connections are made into the opposite side of the machined surface upon which the valves are mounted with sealing ring type gaskets. The concealed piping also results in improved appearance.

Contact the Vickers Application Engineering Office nearest you for suggestions on how Vickers Hydraulic Equipment can improve your machinery.

All hydraulic control units for the machine are included in this group. Flow control valve adjustments convenient to operator without opening panel box.

WRITE FOR NEW BULLETIN, 48-27

This bulletin will give you useful information regarding applications, advantages and installation drawings for Vickers Gasket Mounted Solenoid Controlled Directional Valves.



New Colonial Model RD-10-42 Pull-Down Broaching Machine has Vickers Hydraulic Controls.

VICKERS Incorporated
DIVISION OF THE SPERRY CORPORATION
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Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT
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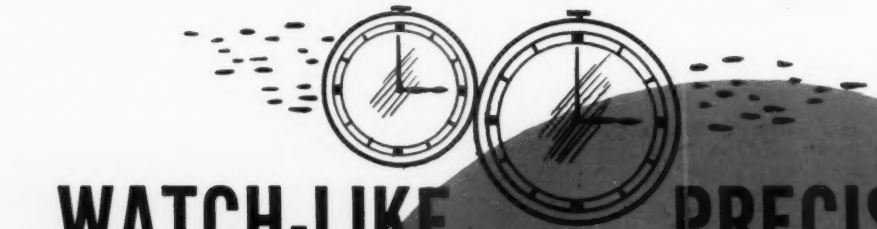


WATCH-LIKE PRECISION FOR *fine* PERFORMANCE

THIS "SIMPLE" STRIP-TYPE HALF BEARING IS CHECKED *51 TIMES* BEFORE RELEASE

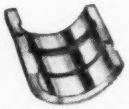
In an internal combustion engine, in the boom of an excavator, or in the landing gear of an airplane, sleeve bearings and bushings are the equivalent of jewels in a watch. They must meet high precision standards.

The Federal-Mogul babbitt-lined bearing pictured above passes through 18 precise, major manufacturing operations in "strip" production. During this period it must pass muster in 51 measurement checks, visual examinations, analysis, temperature and special tests. Just one production operation immediately requires checking wall thickness in at least six places, crush relief in at least four places and detailed visual scrutiny of the finished lining surface.

To produce the fine performance your specifications call for there can be no compromise at any point in manufacture. Our six sleeve bearing manufacturing plants—the result of 49 years' specialization—with extensive research and engineering facilities, can combine quantity, low cost and quality in bearings that will do your job well. Your inquiry is invited.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.



HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

Power goes to work smoothly through

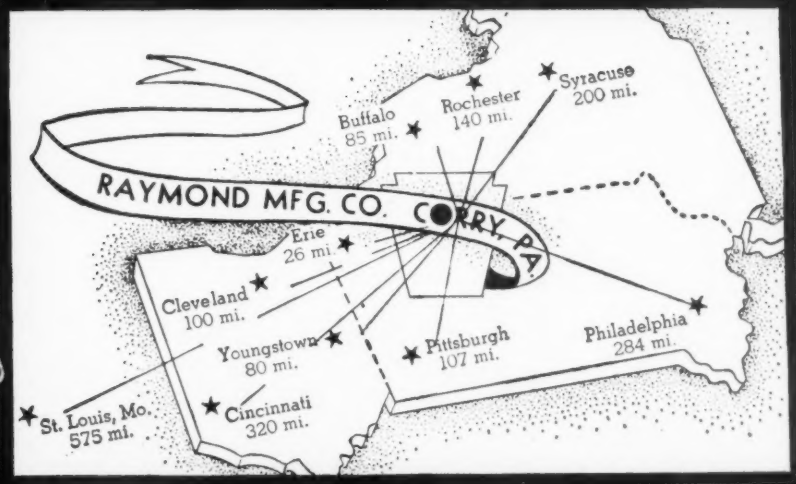
FEDERAL-MOGUL

FEDERAL-MOGUL CORPORATION — **11043 SHOEMAKER, DETROIT 13, MICH.**

FEDERAL Mogul — *Silent* SLEEVE BEARINGS

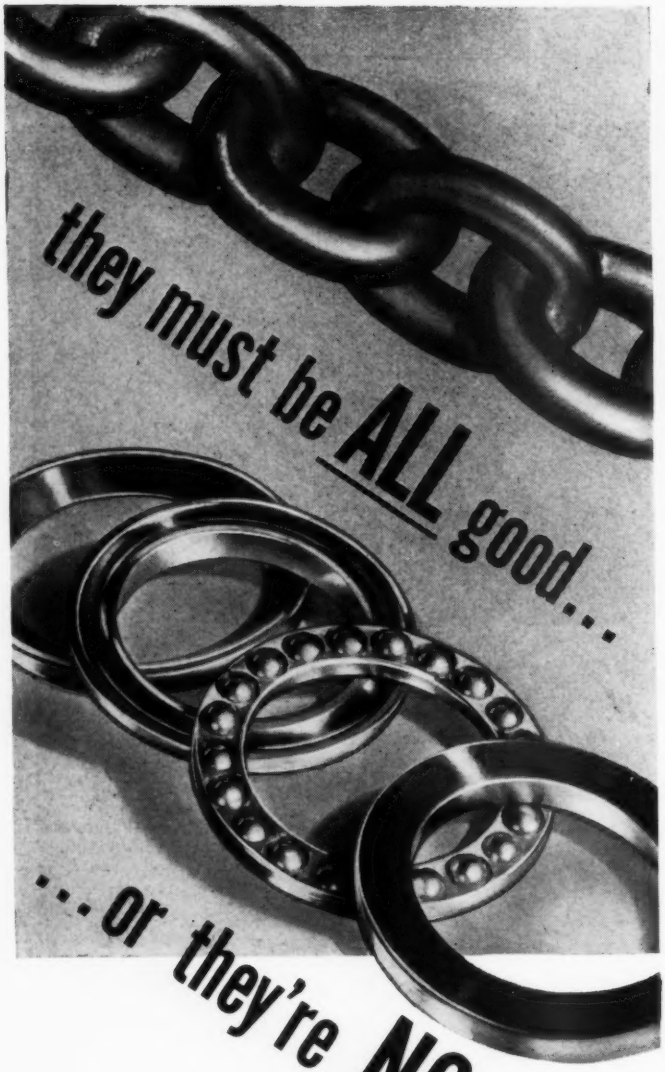
A Source for Springs

IN THE CENTER OF THINGS!



Raymond
SPRINGS
WIRE FORMS · SMALL STAMPINGS
Raymond Manufacturing Co.
DIVISION OF ASSOCIATED SPRING CORPORATION
Corry, Pennsylvania

Here's real help—close by—when you need simple or intricate spring shapes—metal stampings—or wire forms. Raymond serves from start to finish—with engineering design, production efficiency, special finishes and inspection operations—everything you need for complete spring satisfaction.



It's as true with a bearing as it is with a chain—if there's one single weakness it won't stand the gaff.

Should we who design and make Aetna bearings for the World's greatest industries forget that simple truth . . . Then, and justly so, we can expect industry, both great and small, to forget Aetna.

New 52 page catalog available on request

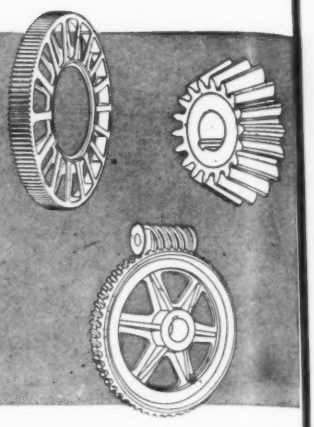
AETNA BALL AND ROLLER BEARING COMPANY
4600 SCHUBERT AVENUE • CHICAGO 39, ILLINOIS

Aetna

BALL AND ROLLER BEARINGS

STANDARD AND SPECIAL BALL THRUST BEARINGS • SPECIAL ROLLER BEARINGS • ANGULAR CONTACT BALL BEARINGS • BALL RETAINERS • HARDENED AND GROUND WASHERS • SLEEVES • BUSHINGS

EXACTLY WHAT *You* WANT



FOR well over 40 years we've been making gears of all types from any practical material in diameters ranging from inches up to 30 feet. We make racks, speed reducers and special machinery, too.

And we are proud of the fact that, in those 40 years, we have given our customers complete satisfaction.

Long ago, we found that it was "good business" to give you exactly the kind of work you want—to take an individual interest in every product that leaves our plant. And we do.

That's why we think it would be "good business" for you to ask Earle for estimates on your work. The Earle Gear and Machine Company, 4710 Stenton Ave., Philadelphia 44, Pa.; Sales Offices: 149 Broadway, New York 6, N. Y.; 901 Davis Ave., Pittsburgh 12, Pa.

IT'S GOOD BUSINESS TO DO BUSINESS WITH *Earle*

EARLE GEARS

WRANGLING *is OUR specialty too!*

In fact, for nearly 50 years ESCO has successfully tackled special electrical problems the world over. Whatever you require in specially designed rotating electrical equipment — motors, converters, dynamotors, special DC, AC, and universal motors — ESCO knows the answer. Not only are our units engineered to meet your exact need, every unit that leaves ESCO is tested to guarantee satisfaction. Each and every unit is dynamically balanced and individually tested under load conditions. Do not hesitate to send us your problem. ESCO will provide applicable data without obligation.

Made to Order

ELECTRIC MOTORS • GENERATING PLANTS • GENERATORS
MOTOR GENERATING SETS • DYNAMOTORS • CONVERTERS

Electric Specialty Co.
170 SOUTH STREET, STAMFORD, CONN.

ESCO

Low Maintenance Cost . . .

High Machine Production

The Dollars-and-cents Advantages of the Airflex Principle

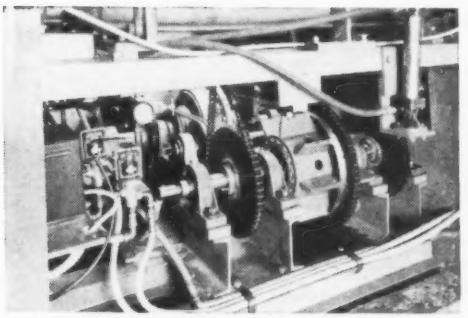
The experience of thousands of satisfied users proves that Fawick-equipped machines do more work—at less cost—and earn more money.

Fawick Clutches adjust themselves. They put an end to wasteful clutch-adjustment down time. They contain no arms, levers or springs to wear or break. In fact, they reduce clutch maintenance costs practically to zero.

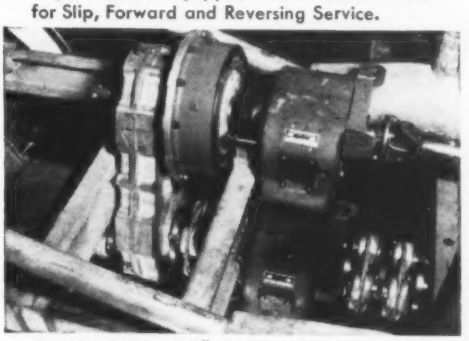
Furthermore, a Fawick Clutch is a shock absorber that protects the entire machine, reduces over-all maintenance expense and adds years to its productive life. It cushions and absorbs shocks, jars, jolts and vibration, preventing unnecessary breakage, undue wear and tear and needless parts replacement costs.

The Airflex principle has proved its advantages under exacting conditions in many fields—petroleum, earth-moving, metalworking, rubber, pulp, paper and others. New applications are being developed constantly.

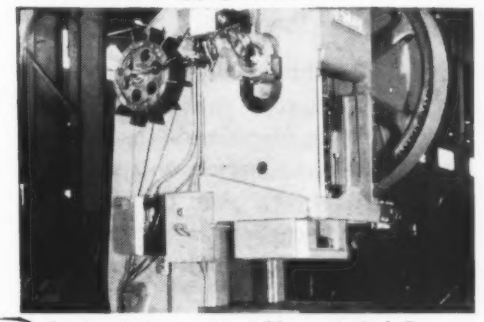
Write our Engineering Department for recommendations of the Fawick elements best suited for your equipment.



Roofing Machinery Company Automatic Roofing Paper Machine equipped with Fawick Clutches for Slip, Forward and Reversing Service.



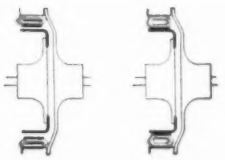
Fawick Airflex 10" Constricting-type Clutch and Fawick Rotorseal on Pointer Willamette "SKYHOOK" Logging Machine.



Lombard Corporation 150-ton O. B. I. Press equipped with 26" Fawick Constricting-type Clutch and 24" Fawick Expanding-type Brake.

HERE'S HOW IT WORKS

Compressed air expands the rubber-and-fabric tube to engage clutch with any degree of "grip" you want. Release the air and clutch disengages.



FAWICK *Airflex* and AIRING **CLUTCH**

FAWICK AIRFLEX CO., INC. 9919 Clinton Rd., Cleveland 11, O.

In Canada, Renold-Coventry Ltd., Montreal, Toronto, Vancouver, Quebec • *In Britain,* Crofts Engineers, Ltd., Bradford, England

There's a Pittsburgh Power Driven Brush for every Industrial Use!

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Pittsburgh brushes are specifically designed to meet your particular finishing requirements. They're tough enough, stiff enough to resist abrasions. They're soft enough to improve surface texture. And the perfect balance of Pittsburgh brushes carefully controls distribution of the brushing stock—provides top efficiency, enduring economy.

In the complete Pittsburgh line are brushes of all types. "Perfect Balance" sections. Wheels and assemblies. Uni-fill scratch brushes.

Consult the Pittsburgh engineering representative today. He'll gladly work with you in developing any type of power-driven brush. And you can be sure it'll do the job right!

FREE!

Steel rule and depth gauge, 6", complete with pocket clip, and atttractive leather case. Yours for the asking . . . write Pittsburgh Plate Glass Company, Dept. W-2, Baltimore 29, Md.

Power Driven BRUSHES

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PITTSBURGH PLATE GLASS COMPANY

Another Great Line!

NEW DELCO MOTORS

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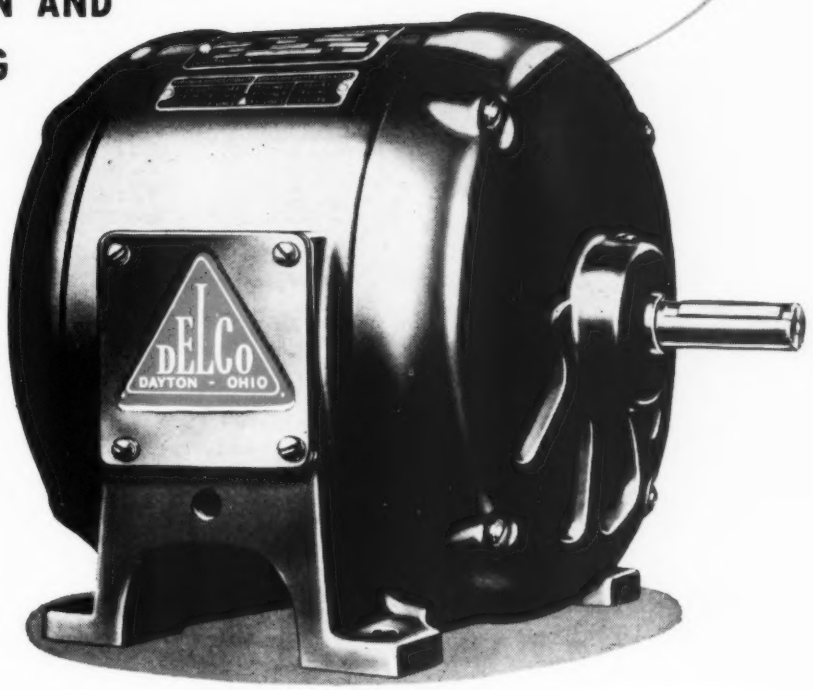


CHECK THESE FEATURES OF THE NEW DELCO MOTOR

- ✓ The inner and outer races of the ball bearing on the end opposite the drive end are locked to give maximum thrust capacity.
- ✓ Polyphase motors have double squirrel cage rotors; die cast aluminum conductor bars and end rings.
- ✓ Close tolerance air gap between rotor and stator.
- ✓ Main frames, end frames of rigid cast iron construction.
- ✓ Extended accessible mounting feet cast as unit with main frame.
- ✓ Single phase available from 1 h.p. through 5 h.p. and polyphase available from 1 h.p. through 7½ h.p. 1800 R.P.M.

Developed especially for compressor service, this new line of Compressor Duty Motors by Delco embodies everything needed to assure long, dependable operation in air conditioning and refrigeration equipment.

The new Delco Compressor Duty Motors are quiet and smooth-running. They're compact, self-ventilated, thoroughly insulated. The rugged cast iron frame permanently protects the inner working parts. The double shielded ball bearings are provided with ample lubrication.

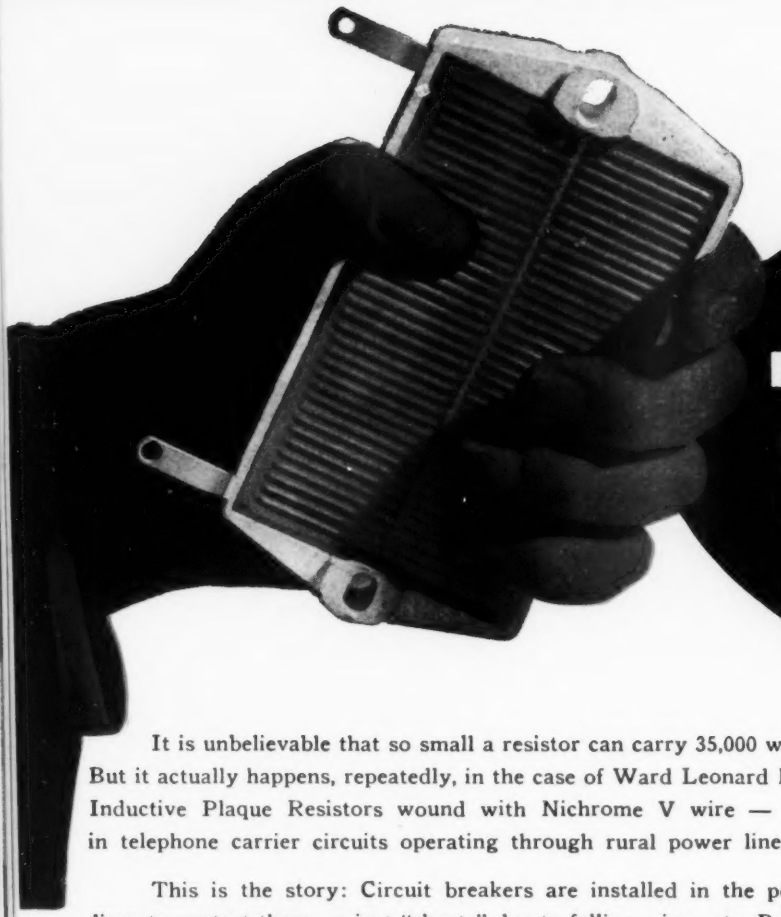
These are just a few of the reasons why this new Delco line will do a better job of powering your compressors. For the full story of their value and quality, write to Delco Products, Dayton, Ohio, or our nearest Sales Office.

DELCO PRODUCTS DAYTON, OHIO

DELCO MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS CORPORATION

SALES OFFICES: CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HARTFORD



HAND-SIZE 50-OHM NICHROME* RESISTOR SHRUGS OFF 35,000-WATT WALLOPS!

It is unbelievable that so small a resistor can carry 35,000 watts! But it actually happens, repeatedly, in the case of Ward Leonard Non-Inductive Plaque Resistors wound with Nichrome V wire — used in telephone carrier circuits operating through rural power lines.

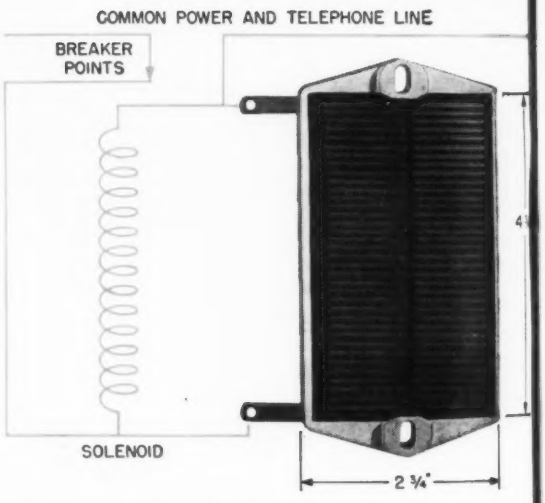
This is the story: Circuit breakers are installed in the power lines to protect them against "shorts" due to falling wires, etc. But the telephone carrier currents are blocked by the high impedance of the breaker solenoids. A low-impedance resistor is therefore used as a by-pass at each solenoid.

When a "short" occurs, the resistor must be momentarily able to carry amperage far in excess of its normal rating, because mechanical lag prevents the circuit breaker from opening instantly. The same applies when lightning, or accumulated static charges, discharge to the ground.

Tremendous strain is imposed upon the winding of the resistor during the instant of high current impact, yet it must stand up.

To assure maximum performance and dependability, Ward Leonard uses windings of Nichrome V. This superlative Driver-Harris alloy sustains tremendous voltage surges without loss of characteristics, retains its superb stability in spite of severe thermal shock, stays on the job even though "jolted" again and again . . . when a breaker makes several attempts to restore an open circuit.

Whatever *your* electrical resistance problems — conventional, unusual, or seemingly impossible of solution — send your specifications to us. We manufacture and draw the most complete line of electrical resistance alloys in the world.



Designed to protect telephone circuits that utilize power supply lines, this resistor, rated at 50 ohms and 125 watts, is intended normally to carry a current of about 1.6 amperes. In the event of short-circuit, however, it will tolerate 16 times this amperage, and a voltage increase producing 35,000 watts, for the fraction of a second required by a power line circuit breaker to operate. Cooling in less than a second after sustaining such an abnormal current impact, the winding, of .010 in diameter Nichrome V wire, remains unimpaired. In fact, this severe treatment can be administered for 3/100ths of a second per second for 3 successive seconds without damage to the resistor. Made by Ward Leonard Electric Co., Mount Vernon, N. Y.

SPECIAL PURPOSE ALLOYS SINCE 1900 — D/H — TRADE MARK REG. U. S. PAT. OFF.

Nichrome is Manufactured only by

Driver-Harris Company

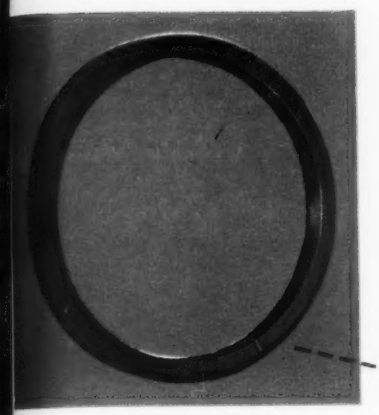
HARRISON, NEW JERSEY

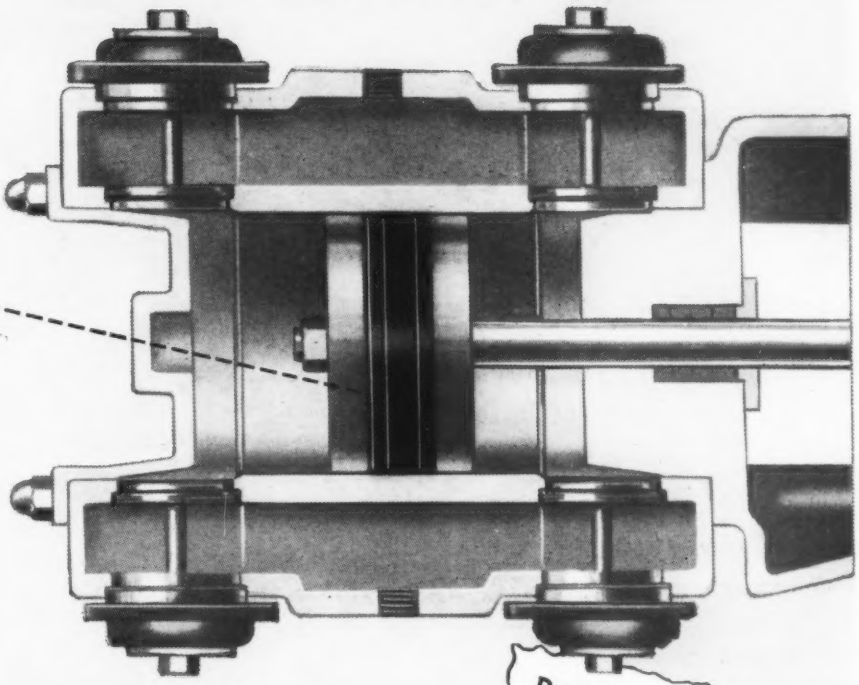
BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle
Manufactured and sold in Canada by
The B. GREENING WIRE COMPANY, LTD., Hamilton, Ontario, Canada

*T.M. Reg. U. S. Pat. Off.

DRY LUBRICATION

prevents contamination in this compressor cylinder





MORGANITE
SELF-LUBRICATING CARBON PRESSURE RINGS

—avoid the introduction of oil into compressed air or gas stream

Prior to the application of Morganite piston rings, the introduction of liquid cylinder lubricants into the air or gas stream seriously affected, and often prohibited, the use of compressors. Food contamination in processing, danger of explosion and inaccurate instrument readings were just a few drawbacks. Various remedies—including extractors and other auxiliary equipment — were tried. In no case were results entirely satisfactory, and where auxiliary equipment was used, maintenance costs were high. Morganite Pressure Rings solved the problem. They require no lubrication, are chemically inert, impart no taste or color. Mechanically strong, these rings may be repositioned to compensate for wear before renewal is required.

Manufacturers, product designers, production and maintenance officials will find Morganite offers features that reduce operating costs and improve product quality. Illustrated literature on pressure seals, bearings and specialties is available for your files; address Carbon Specialties Dept. PR.

REGISTERED TRADE MARK

Morganite INCORPORATED

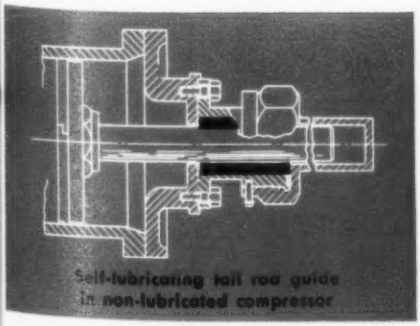
LONG ISLAND CITY 1, NEW YORK

Draw on the MORGANITE Backlog of Experience

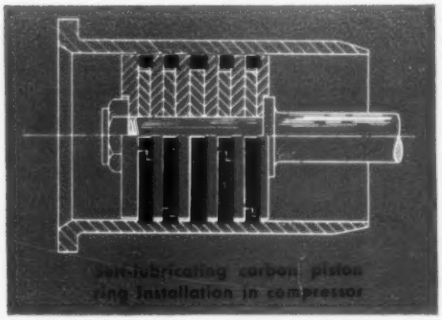
for BETTER METHODS BETTER PRODUCTS

Versatile enough to solve countless stubborn problems in mechanical, chemical and electrical engineering — flexible enough to fit into almost any machine design, Morganite is a stock pile of extra operating efficiency. The compressor problem illustrated, simply and permanently solved by Morganite, stumped chemical and food processors for years. This is only one of thousands of actual case histories that illustrate the Morganite Backlog of Experience which you may find it profitable to draw upon.

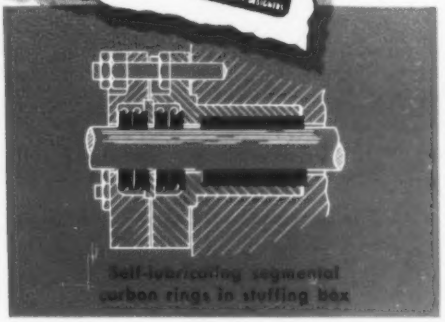
See our CATALOG in SWEET'S FILE



Self-lubricating tail rod guide in non-lubricated compressor



Self-lubricating carbon piston ring installation in compressor



Self-lubricating segmental carbon rings in stuffing box

Happy thoughts for holiday profits

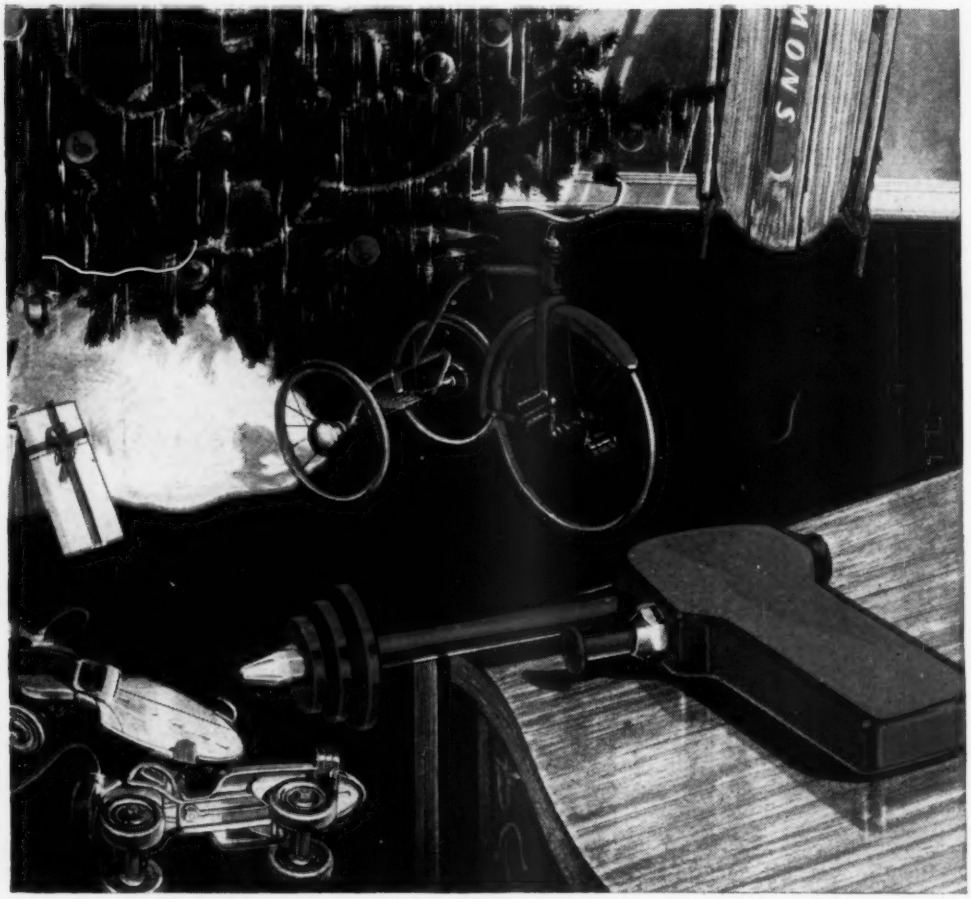
LOOK BEYOND the "yippees" of delight that greet these toys on Christmas Day . . .

You'll find their elated manufacturers closing one of their biggest, brightest seasons.

For each toy, in its way, is better, stronger, safer and *a bigger hit* than one of other years, thanks, in part, to the happy thought of using Bundy Tubing.

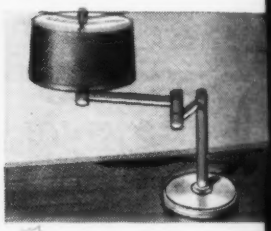
See the barrel of the water pistol . . . and the sled runners? Or the spacers between the roller skate wheels and the tricycle frame? These are only *hints* of how Bundy helped spell bigger holiday sales.

Better check into Bundy yourself. You'd be amazed at where you can use this miracle tubing of industry. The examples at the right range from some standard uses of Bundy to some new ideas well worth pondering. Study them carefully.

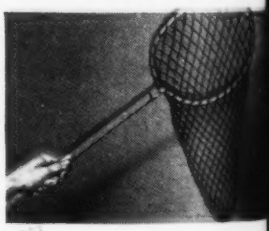


1 Double-walled, tough and
bration-proof, Bundyweld* t
tubing is in hydraulic brake line syste
of 95% of today's trucks and cars. If
pressure lines must take a beati
better think of Bundy, too.

2 Bundy is a top performer
the machine tool field, too . . .
a tubing for coolants, lubricants a
pressure lines. Bundyweld* is doub
walled from a single strip. Available
steel, Monel or nickel.



3 Wherever it's used, fro
umbrella stems to lamp shad
frames and lamp arms, Bundy gives
plus in profits or design. It's thinne
walled, lightweight, machineable, du
tile. Which reminds us . . .



4 If you make fishing tackl
why not check into Bundy fo
landing net frames? We've never see
Bundy used this way, but it's a sugge
tion that might start *you* toward an ev
sturdier, better product.

5 Or here's another idea:
carriage chassis of Bundy for
more toy sales next Christmas. If you
interested, we'll be glad to work
you. No other tubing offers so ma
profitable possibilities.

BUNDY TUBING

ENGINEERED TO YOUR EXPECTATIONS

*REG. U.S. PAT. OFF.

6 WHATEVER YOUR design or production problem, whatever the idea you may be wrestling with, there's more than an even chance that a simple application of Bundy Tubing can help you put it over, and lead you to a better product, made faster, more easily and at less cost. Why not see what Bundy engineers can do. Just call or write: *Bundy Tubing Company, Detroit 14, Mich.*

WHY BUNDYWELD IS BETTER TUBING

BundyweldTubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong, ductile tube, free from scale, held to close dimensions.

Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. Special sizes can be furnished to meet your requirements.

Bundy Tubing Distributors and Representatives: *Cambridge 42, Mass.:* Austin-Hastings Co., Inc., 226 Binney St. • *Chattanooga 2, Tenn.:* Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • *Chicago 32, Ill.:* Lapham-Hickey Co., 3333 W. 47th Place • *Elizabeth, N.J.:* A.B. Murray Co., Inc., Post Office Box 476 • *Philadelphia 3, Penn.:* Rutan & Co., 404 Architects Bldg. • *San Francisco 10, Cal.:* Pacific Metals Co., Ltd., 3100 19th St. • *Seattle 4, Wash.:* Eagle Metals Co., 3628 E. Marginal Way • *Toronto 5, Ont., Canada:* Alloy Metal Sales, Ltd., 881 Bay St. **Bundyweld nickel and Monel tubing is sold by International Nickel Company distributors in all principal cities.**

MADE FROM
REVERE
STRIP
Revere produces the following metals in strip form:
COPPER
BRASS
BRONZE
NICKEL SILVER
CUPRO-NICKEL
in a wide variety of gauges, widths, lengths and tempers

REVERE STRIP and ROLLS for fast, economical fabrication

REVERE Metals in strip and roll form are widely used throughout industry for the manufacture of parts and products by such processes as deep drawing, stamping, punching, spinning, embossing, rolling, etching, soldering, polishing, plating.

Special finishes, such as embossed, polished, etc., are available from the mill for some alloys and forms. Naturally, the value of such finishes depends upon two main factors: the fabrication processes through which the metal is put in your plant, and the nature of the articles or parts you make. Where suitable, special finishes often reduce costs and improve the beauty, attractiveness or service of the finished product.

BRASS

Brass is an old and honored metal, corrosion-resistant, and adaptable to a wide range of fabrication conditions, from simple stamping to exceptionally deep drawing, as in cartridge cases. Yet it should be remembered that brass is not just brass. There are many different brasses which vary in their composition. In addition, each brass alloy can be had in a variety of physical conditions. By rigid control of processing in the Revere Mills, strict specifications as to temper, hardness, and grain size are met.

COPPER

Revere produces several types of copper for various applications. All contain over 99% pure copper, but some contain in addition traces of other elements which adjust the physical qualities to meet special needs. Electrolytic Tough Pitch Copper in strip form is widely used for the manufacture of electrical parts by stamping and drawing.

GENERAL CONSIDERATIONS

The importance of a careful study of both composition and physical properties cannot be stressed too often. It might be, for example, that a difference in alloy, temper, gauge or dimensions would make manufacturing economies possible.

Sometimes a reduction in the cost of the material can be achieved by slight changes in specifications, without affecting fabrication or service of the part. To this saving may be added an additional one—reduction in amount of scrap. Though scrap has a high re-sale value, reduction in the amount of it should result in lower unit costs.

CARTRIDGE BRASS, 70%

(Seventy-Thirty Brass). Alloy No. 160. (Copper 70.0%, zinc 30.0%).

Forms Available: Sheet, strip, tube, rod, rectangular bar and lockseam tubing.

General Properties: Revere Seventy-Thirty Brass has the best combination of ductility and strength of all the brasses and accordingly has superior cold-working properties.

Typical Uses: Seventy-Thirty Brass is recommended for difficult deep drawn, stamped or spun parts, cartridge cases, ammunition components.

Working Properties: Cold-working, soldering, polishing—excellent. Hot-working—good. Machining—fair. Welding—gas, carbon arc, metal arc, spot and seam welding for thin gauge.

ASTM Specifications: Sheet: B19, B36. Tube: B135. Rod: B134.

ELECTROLYTIC TOUGH-PITCH COPPER

Alloy No. 100. (Copper 99.90%, minimum).

Forms Available: Sheet, strip, plate, rod, bus bar, tube, forgings.

General Properties: This copper combines high electrical and thermal conductivity with excellent working qualities. It resists corrosion, and is a favorite for parts that are to be plated.

Typical Uses: Electrolytic Copper is recommended for stamped and drawn parts such as escutcheons, lamp sockets, housings; for electrical equipment and conductors; for roofing, flashing, gutters; process equipment; printing rolls; forgings.

Working Properties: Cold-working, hot-working, soldering, polishing, plating—excellent. Machining—fair. Welding—deoxidized copper preferred.

ASTM Specifications: Sheet: B11, B101, B152. Rod: B12, B48, B49, B124, B133, B187. Tube: B13, B111, B188.

PHOSPHOR BRONZE, 5% (A)

Alloy No. 308. (Copper 95.0%, tin 5.0).

Forms Available: Sheet, strip, rod.

General Properties: Revere Phosphor Bronze, grade A, possesses high tensile strength, high resistance to corrosion and fatigue and has a low friction coefficient. It is also highly resistant to season cracking.

Typical Uses: Revere Phosphor Bronze, grade A, is used for springs, diaphragms, bellows, lock washers, cotter pins, fuse clips, clutch discs, screw machine stock, perforated sheets, etc.

Working Properties: Cold-working, soldering, polishing—excellent. Hot-working—poor. Machining—fair. Welding—gas, carbon arc, metal arc, spot and seam welding for thin gauge.

ASTM Specifications: Sheet: B100, B103. Rod: B139, B159.

HERCULOY (Silicon Bronze)

Alloy	Copper	Silicon	Manganese
420	96.0%	3.0%	1.0%
421	98.00%	1.75%	0.25%

Forms Available: Sheet, strip, plate, rod, wire, tube, forgings.

General Properties: Herculoy has excellent mechanical properties. The strength of Herculoy is comparable to that of low and medium carbon steel. Its resistance to corrosion is similar to that of copper. It is non-magnetic and gold colored.

Typical Uses: Herculoy is recommended for welded tanks, pressure vessels (unfired pressure vessels codes), vats, baskets, chemical equipment, etc.; Herculoy 421 for hardware, bolts, screws, lag screws, cotter pins, washers, turnbuckles, marine construction, screens, filters, ducts, weatherstrips, springs, forgings.

Working Properties: Cold-working, soldering—excellent. Hot-working—good. Machining, polishing—fair. Welding—gas, carbon arc, metal arc, spot and seam welding for narrow gauge.

ASTM Specifications: Sheet: B96, B97, B100. Rod: B98, B99, B124.

The following Revere Metals are also produced in strip and roll: Copper: Silver-bearing, Deoxidized, Oxygen-free — Nickel Silver — Admiralty — Commercial Bronze, 90% — Red Brass, 85% — Yellow Brass — Naval Brass — Cupro-Nickel.

On this page you will find technical data on only a few of the Revere Metals produced in strip and other forms as well. If you require further information, get in touch with any Revere Office or distributor.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.

Sales Offices in Principal Cities, Distributors Everywhere.

Nothing pleases Revere more than to be able to sit down with a customer and discuss fabrication methods and end uses. Such friendly collaboration often has resulted in increased production, lower costs, an improved product, or all three. In one case, substitution of leaded brass for yellow brass was suggested, for greater ease in blanking and to reduce the need for dressing down with a file after assembly. In another, a slight change in gauge reduced material cost. In still another, a different temper eliminated one anneal. The Revere Technical Advisory Service will be glad to work with you on your problem.

Harnessing 100 Horses for a 1600 TON WALLOP

DAYTON V-BELTS
re-accelerate faster
last longer
save space

This giant 1,600-ton Ajax solid frame Forging Press produces highly accurate differential ring gear blanks and many other types of multi-stage forgings. 9 V-Belts transmit the power from a 100-h. p. motor.

Industrial Designers!

All standard Dayton V-Belts have the extra strength of Raytex Fortified Cords...Dayton's specially processed Rayon cords that make possible minimum stretch, maximum strength and longer life! For the complete story, write today for Booklet A-469.

Transmitting the power from a 100-h. p. motor to the flywheel of this forging press is a perfect example of the superiority of Dayton V-Belt Drives. Here, maximum drive efficiency, rapid re-acceleration after flywheel slowdown, continuous operation and compactness of the drive are advantages the designer desires.

And he gains them all with Dayton V-Belt Drives. First, Dayton V-Belts are the most efficient method of transmitting power known. They withstand the stresses and strain of sudden starts, stops and shock loads. They transmit full power, fast. They flex around the pulley easily, without heating. And they save space by permitting the use of shorter centers, smaller pulleys.

Made with super-strength Raytex Fortified Cords, Dayton V-Belts offer minimum stretch, maximum strength, longer life. They are unaffected by oil, heat or abrasive conditions. No matter what your power transmission problem, there is a Dayton V-Belt Drive that will solve it perfectly. Dayton Power Transmission Specialists stand ready to help you at any time. Write or phone *The Dayton Rubber Company, Dayton 1, Ohio, today.*

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

You're OK with P-K *for...*

A new standard of quality and *uniformity* has been pioneered by P-K in the quantity production of Cold-forged *Ground Thread* Socket Set Screws. Ground on hardened blanks, threads are mirror-smooth, assure a dependable Class 3 Fit. Consistently uniform and free from nicks, burrs and hardening scale, they have none of the imperfections common to cut threads.

Compare! *Ask for Samples.* See why P-K Ground Thread Socket Set Screws are different from ordinary set screws as night and day. You'll agree your products will benefit — assembly - wise and sales - wise! Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

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GOOD JUDGMENT CALLS FOR

PARKER-KALON

WHEN GOOD DESIGN CALLS FOR

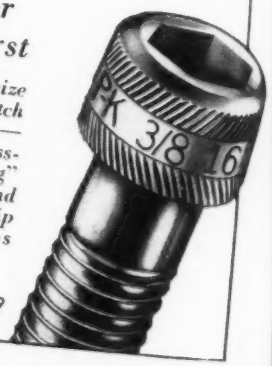
SOCKET SCREWS

SOLD ONLY BY ACCREDITED DISTRIBUTORS

SIZE-MARKED • GEAR GRIP* SOCKET HEAD CAP SCREWS

Another P-K First

Gives you size and thread pitch at a glance — eliminates guessing or "miking" — saves time and errors. Gear Grip prevents slips and fumbles.



*U. S. Pat. No. 126,409

You peek into the plastic window of this plastic bowl... turn a plastic knob — and a Sterling Salt Tablet, falling thru a plastic baffle plate, is dispensed onto your palm!

This Structurally Fit

20 Ounce

(1500 Salt Tablet Capacity)

Plastic Dispenser Exemplifies Sound Engineering, Correct Material Choice and Precision *Follow-thru* Processing

This presentation, by courtesy of International Salt Company enables you to picture, as you read, one of Consolidated's recent achievements—in blue Urea plastic! By thus making the dispensing of Sterling Salt Tablets available to the public, *International's* thought is to allay thermoplegia or heat sickness . . . Consolidated's way of serving its custom-public is to preclude heat sickness by dispensing year-in and year-out plastic satisfaction! The calendar shows that we have been doing this for industry since 1874. May we so serve you?

LEGEND . . . Mechanical Structure View of Sterling Salt Dispenser, shown above, refers to (A) Plastic Cap. (B) Hollowed Plastic Body. (C) Slotted Plastic Wall Support. (D) Rotating Plastic Baffle Plate. (E) Transparent Plastic Window. (F) Rotating Plastic Knob . . . Product shown through courtesy of International Salt Company, Scranton, Pa.

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PRODUCT DEVELOPMENT • MOLD DESIGN • MOLD CONSTRUCTION • PLUNGER MOLDING • TRANSFER MOLDING • INJECTION MOLDING • COMPRESSION MOLDING

IRIDITE *gives*

YOUR ZINC DIE CAST PRODUCTS
lasting corrosion protection
...better paint adherence...
colorful, *salable* finishes

By a simple quick dip, manually or in automatic machines, Iridite provides a triple-purpose finish on zinc die cast products—Iridite gives you—

CORROSION RESISTANCE... for protection from air, water, gasoline, other harmful corrosives.

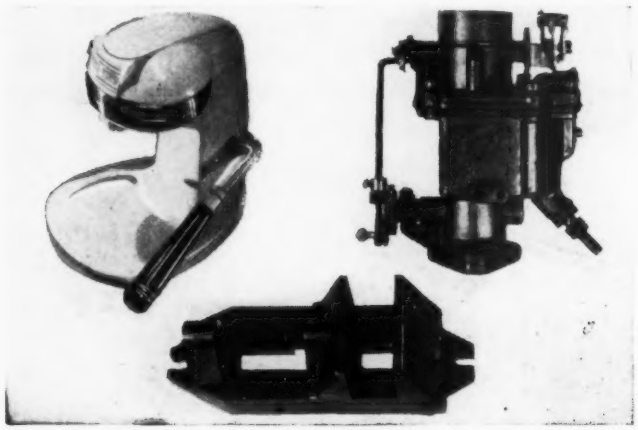
PAINT ADHERENCE... to vastly increase corrosion resistance and to secure a paint system that defies chipping, flaking, peeling

EYE APPEALING COLOR... that protects the product on the shelf, draws the customer's eye.

Iridite is a non-electrolytic chemical process, used and approved by leading manufacturers. If your products use zinc die cast parts, write today for information on how Iridite can help you make a better, more salable product.

JUICER — Fruit juicer, finished with Iridite to insure permanent adherence of sparkling enamel finish.

CARBURETOR — Automobile carburetor, finished with Iridite for protection against corrosion from gasoline, fuel line moisture.



VISE—Bench vise, finished with Iridite to provide permanent blacking and corrosion protection.

Allied Research Products, Inc.
201 CHEMICAL BLDG.
4004 E. MONUMENT STREET • BALTIMORE 5, MARYLAND

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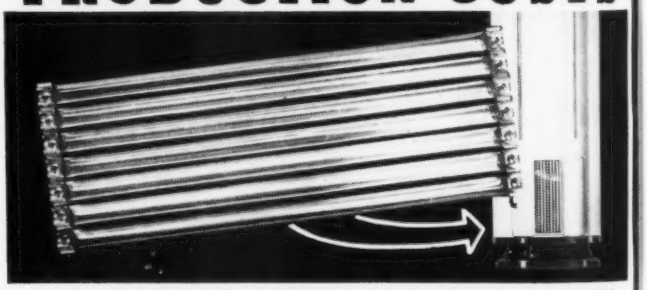
Backed by years of experience, DIEFENDORF maintains its high standards of gear manufacturing —striding constantly forward — meeting and fulfilling new demands of progressive industry.

With individual attention to each gearing problem, DIEFENDORF GEARS are cut precisely to specification. Gears of all types—all metals or non-metallics.

DIEFENDORF GEAR CORPORATION
Syracuse 1, N. Y.

DIEFENDORF GEARS

Cut your
PRODUCTION COSTS



with GREENE MOULDING ASSEMBLIES

Where your product design calls for grille work, louvres, decorative trim, etc., that mean plated castings or one-piece stampings, check the savings Greene UNI • FORM • Moulding Assemblies can make for you. Made by the economical Greene process of assembling low-cost mouldings and stampings, you'll find UNI • FORM Moulding Assemblies give you . . .

- **Lower cost per unit**
- **Equal or greater strength**
- **Reduced weight**
- **Economical repair or replacement**
- **High quality appearance**

ASK FOR IT!

If you use production quantities of parts that can be made by this cost saving process, please send us details, blue prints and quantities required. No obligation on quotations, of course.

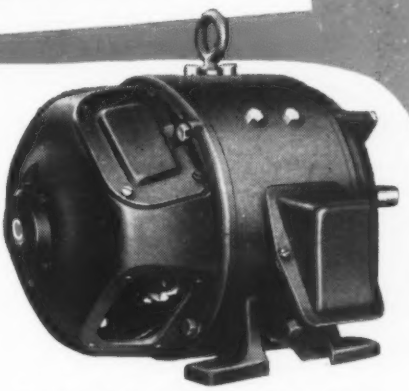
• Trademark

Free Catalog of decorative moulding shapes.

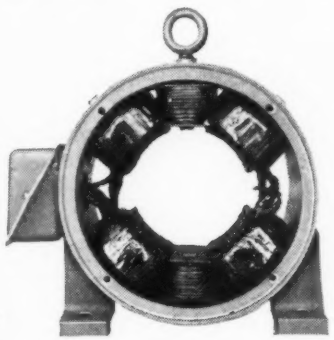
Greene Manufacturing Company Inc.
1028 Douglas Avenue RACINE, WISCONSIN

Century Direct Current Motors

Correct Design, Rugged Construction Mean Long Life and Top Performance



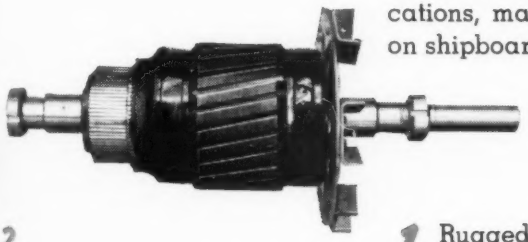
Century 3 horsepower Direct Current open rated (1249A) ball bearing motor, equipped with protecting covers



1

Nearly 50 years of experience and know-how have gone into the development of modern Century Direct Current motors. From this background Century engineers have developed a complete line of DC motors from 1/6 to 300 horsepower — available for any application where direct current is used.

Typical applications are wire drawing machines, steel mill applications, machine tools, motion picture machines, marine equipment on shipboard, cranes and hoists, oil field equipment and applications requiring adjustable voltage speed control.



2

Here are some of the construction features that make them rugged, sturdy, dependable sources of electric power.

3

1 Rugged steel frame with accurate machining. Stays rigid, maintains proper air gap between field and armature. Windings are neat, compact, thoroughly saturated with insulating compound.

2 Armature is built upon a stiff steel shaft. Mica insulated commutator is large. Large fan assures adequate ventilation.

3 Strong, durable brass brush holder keeps brushes securely in position. Rugged construction contributes to long life. (Shown mounted on inside bearing cap.)

4 Illustration is of a splash proof end bracket assembly for ball bearing motor. Accurately machined to maintain shaft in alignment.

4

These and other features of Century Direct Current motors contribute to their long life of top performance.

In addition to DC motors, Century builds a complete line of electric motors and generators from 1/6 to 400 horsepower to meet the requirements of industrial and commercial applications.

Popular types and ratings are available from factory and branch office stocks.

Specify Century motors for all your electric power requirements.

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It's NEW - It's Sensational

The SMALLEST "O" or "I" Size Magnetic Made

ONLY 6 3/16" x 6 11/16" in size of enclosure — *half the size* of vertically-operated magnetics — this Type "RA" Starter is new throughout. Sturdy, dependable, *incomparably compact.*

The *new principle* design with balanced mechanism provides a free-floating magnet with guided contact alignment. Lever and fulcrum action multiplies the leverage, transfers magnet pull from vertical to horizontal plane and increases contact pressure.

Designed for straight-through wiring, with separate contact enclosures. Embodies all the high-efficiency features found hitherto in the Size 3 and Size 2 "RA" Starters.

ARROW AH HART

This New *Size "0"* or *"1"*, Type "RA" provides local control for motors rated 5 H. P., 220 Volts and 7½ H. P., 440 or 550 Volts. Write at once for descriptive folder on this foremost advance in space-saving motor controls.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD 6, CONN., U.S.A.

Here are the advantages of buying

BOTH

hydraulic oils and packings

FROM A SINGLE SOURCE:*

Houghton, with separately organized oil manufacturing and packing departments, is in position to supply *both* fortified hydraulic oils *and* hydraulic packings.

We *know* how oils affect some packings. We know that Houghton packings are not harmed by our Hydro-Drive Hydraulic Oils. We protect our VIM Leather and Vix-Syn synthetic rubber packings against oil attack. And we've tested the results, to be sure.

Our packing and lubrication engineers work together on design problems. They call each other in for reciprocal aid, to provide the best service to our customers. So if yours is a hydraulic problem and you want the right oil, correctly sealed in, rely on E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. Service and Sales in all principal cities.

Write for your free copy of this revised Handbook. It's a helpful reference.

* Houghton is the only company that supplies both!

HOUGHTON'S

HYDRO-DRIVE OILS *and*

VIM & VIX-SYN PACKINGS

This beats a magic carpet!

Air Express can bring you supplies and equipment from any U. S. point—*overnight*. And that's better than old-style magic! Air Express is the fastest way you can find to ship or receive. No delays, because shipments go on every flight of the Scheduled Airlines.

What's more you get special door-to-door service at no extra cost. With low Air Express rates, you can use this fastest service as a regular procedure. Let Air Express keep your business running fast—and smoothly.

Specify Air Express-World's Fastest Shipping Service

- Low rates—special pick-up and delivery in principal U.S. towns and cities at no extra cost.
- Moves on all flights of all Scheduled Airlines.
- Air-rail between 22,000 off-airline offices.

True case history: Rubber equipment users regularly get replacement parts by Air Express so machines won't stand idle. Recent shipment: 102-lb. carton picked up 5 P.M. the 18th in Noblesville, Ind. Air-rail to Dallas, delivered 9 A.M. following day. 799 miles, total cost only $26.78. Any distance inexpensive, too. Phone local Air Express Division, Railway Express Agency, for fast shipping action.

AIR EXPRESS
AIR EXPRESS GETS THERE FIRST

Rates include pick-up and delivery door to door in all principal towns and cities

AIR EXPRESS, A SERVICE OF RAILWAY EXPRESS AGENCY AND THE
SCHEDULED AIRLINES OF THE U. S.

6 times THE POWER OF ORDINARY SOLENOID VALVES

GENERAL CONTROLS
K-10 SERIES
ELECTRO-MAGNETIC
LEVER VALVES

CONTROLS: LIGHT AND HEAVY OILS, AIR, WATER, GAS, STEAM, REFRIGERANTS, etc. Suitable for pressures up to 1000 pounds and temperatures up to 400° F.

SIX TIMES THE POWER of ordinary solenoids assures high seating pressure and overcomes the blocking effect of viscous fluids, such as heavy fuel oil. Adequate power of solenoid insures positive operation. Normally closed or open types available.

Internal valve assembly can be removed for cleaning and inspection if necessary. Two-wire—A.C. or D.C.—current failure—packless construction—bronze body—stainless steel and bronze internal parts—soft seats available.

FOR COMPLETE SPECIFICATIONS *request new Catalog.*

GENERAL CONTROLS
801 ALLEN AVENUE GLENDALE 1, CALIF.
Manufacturers of Automatic Pressure, Temperature, Level & Flow Controls
FACTORY BRANCHES AND DISTRIBUTORS IN PRINCIPAL CITIES

GET DEPENDABLE
POWER

FROM *DOERR*
SPECIAL APPLICATION MOTORS

■ The majority of our motors are produced to meet the precise operating needs of manufacturers whose basic product design or end-use requires special features.

We are providing such service promptly to many leading names in industry, and would be pleased to consult with you on your motor design problems.

Write for complete information and prices.

74 NORTH THIRD STREET
CEDARBURG, WISCONSIN

FROM 1/20 to 2 H.P.

DOERR MOTORS

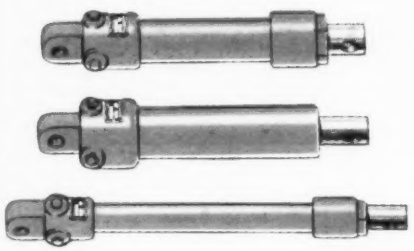
Standard or Designed to Your Specifications

ELECTRO MACHINES, INC.

Blackhawk Low-Cost, High-Pressure Hydraulic Controls Create

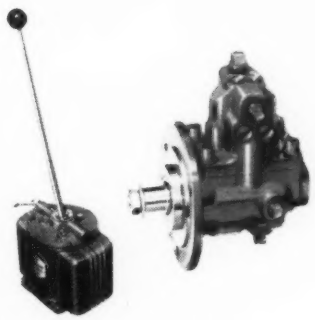
EXTRA SALES APPEAL DEPENDABILITY PERFORMANCE

For Your Product



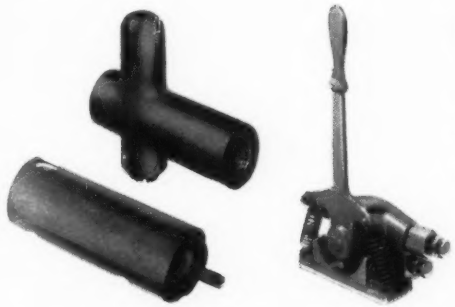
RAMS

Compact Blackhawk Hydraulic Rams are designed for high-pressures up to 10,000 lbs. per square inch. Available in a wide range of standard sizes, there is a Blackhawk Ram to fit your needs. Their amazing compactness means easier installation in tight spots . . . less design change in present equipment . . . greater opportunity to create overall compactness.



PUMPS

Blackhawk makes both power-driven and hand-operated hydraulic pumps. Pumps range in capacity from 2500 to 5000 p.s.i. Because of the high pressures developed, these pumps not only are compact in themselves, but permit smaller oil lines, smaller diameter rams and compact valves.



VALVES

Compact Blackhawk Control Valves permit fingertip control of rams at all times. Valve can be mounted separate from the pump in any position convenient for the operator. This creates ease of handling.

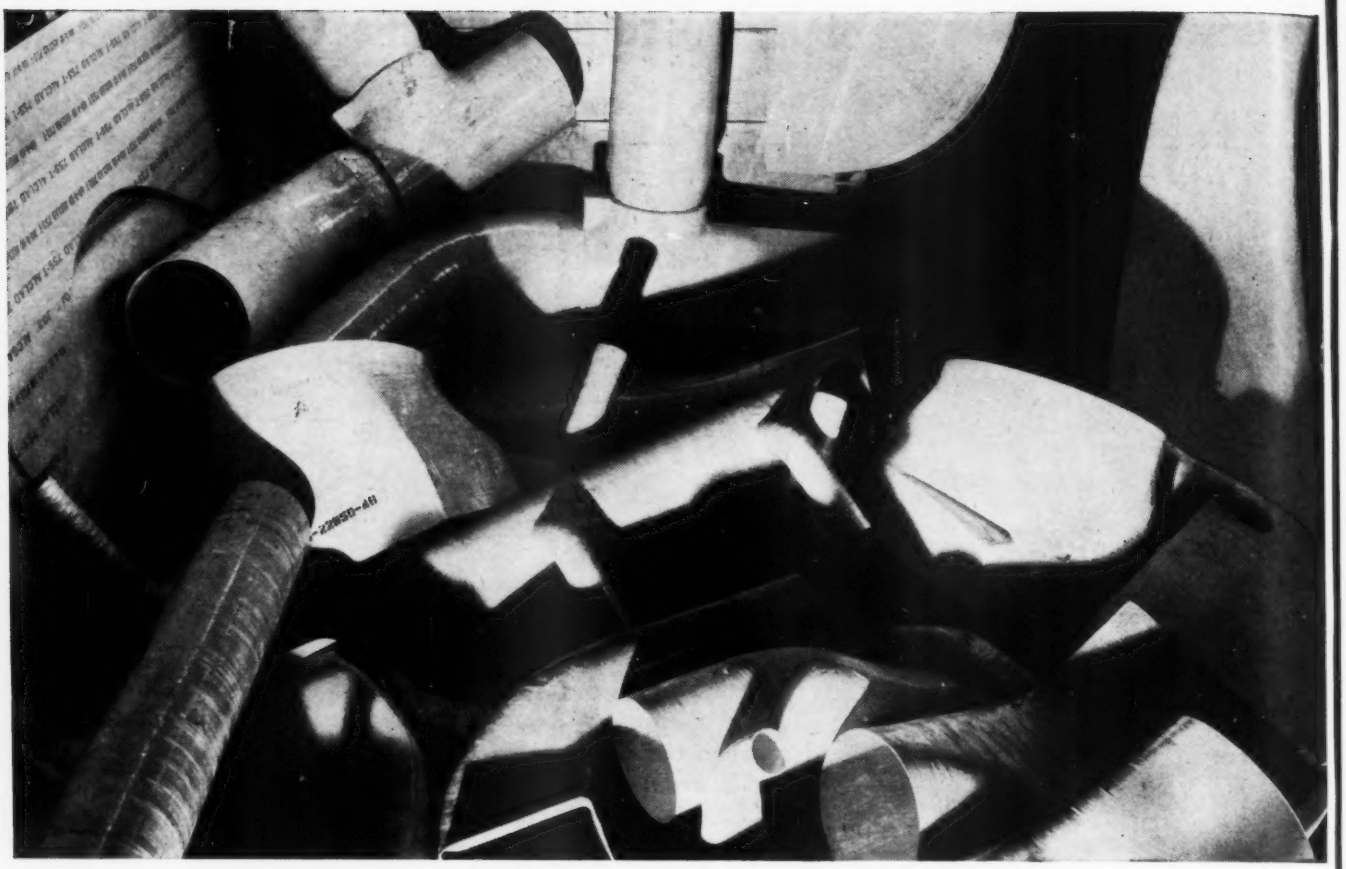
BLACKHAWK MFG. COMPANY • Dept. PE 128 • Milwaukee, Wisconsin

Blackhawk Hydraulic Controls (Pumps, Rams, and Valves) are engineered and priced for quantity purchases and installation on your products. Submit your hydraulic problems to us. We will work with you in confidence.

Write for this new bulletin. It is a practical working guide for the selection of either hand-operated or power-driven hydraulic units.

BLACKHAWK

HAND JACKS • SERVICE JACKS • WRENCHES • PORTO POWER • RECK-RACK



FLYING DUCTS

. . . molded of Fiberglas*-reinforced plastics

275 air ducts (196 different sizes and shapes) are used in building the famous Boeing Stratocruiser. For these intricate molding operations, Boeing engineers found that Fiberglas-reinforced plastics offered a threefold advantage over metal. Complicated shapes could be made in quantity production at less cost; the ducts could be shaped without the restrictions of metal; they represented a weight saving as high as 40%.

Fiberglas reinforcements are helping many designers and manufacturers produce laminated plastics products that are:

- Light in weight and extremely tough.
- Resistant to corrosion and rust.
- Permanently colored: Eliminates original cost of surface finishing—no maintenance cost.
- Easy to fabricate: Can be formed with either high- or low-pressure laminating equipment—at minimum tooling cost.
- Economical: Fiberglas reinforcements are available, today, priced lower than most commonly used laminating reinforcing materials.

For information on the properties, applications, economics and typical methods of fabricating products of plastics reinforced with Fiberglas Mats, Fibers and cloths woven of Fiberglas Yarns—write for a copy of the Fiberglas-reinforced plastics manual A9.3.1. Owens-Corning Fiberglas Corporation, Dept. 807, Toledo 1, Ohio. Branches from coast to coast.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

Photo: Courtesy of Boeing Airplane Company, designers and builders of the Boeing Stratocruiser, C-97 Stratofreighter, B-50 and B-29 Superfortresses and the B-17 Flying Fortress.

OWENS-CORNING

FIBERGLAS

REG. U.S. PAT. OFF.

PLASTICS REINFORCEMENTS

*FIBERGLAS is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers

Oil Foil
From the name you would guess that Oilfoil keeps oil in or out. Correct. But it not only acts as a positive seal. It also is a storage reservoir for oil, which bleeds out as required for bearing lubrication. Further, it is an impervious shield against water, dirt, other foreign matter.
How is this accomplished? An Oilfoil washer or seal is a sandwich of felt and Hycar, the synthetic elastomer that is especially resistant to hydrocarbons. The felt may be of the same type and density throughout, or different felts may be combined with one or more impervious septums, according to the requirements of the specific case. Oilfoil Seals or Washers are usually impregnated with oil, grease, graphite or other lubricants before assembly.
Originally developed by us in 1921, these laminated felt seals are now being increasingly recognized as offering the ultimate in protection. Write for full information.
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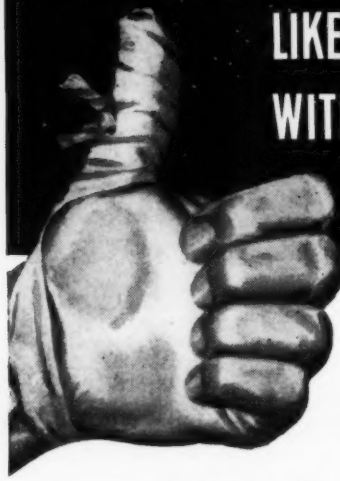
WILL YOUR FASTENERS STICK OUT LIKE A SORE THUMB WITHIN 6 MONTHS

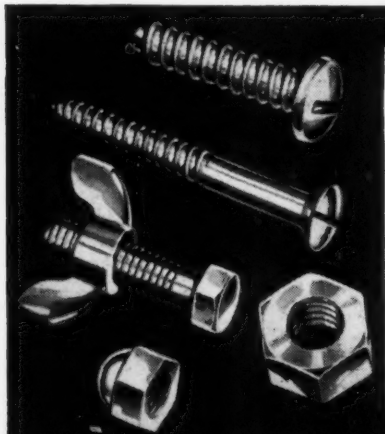


NOT WHEN YOU

FASTEN ALUMINUM **WITH** ALUMINUM

Alcoa Fasteners for aluminum assemblies prevent that sore thumb look that results when galvanic action attacks dissimilar metals and causes corrosion, or when red rust attacks. Alcoa Aluminum Fasteners come bright and stay bright—dress up your aluminum assemblies.

Complete selection—wood, sheet metal and machine screws in a range of types and sizes; washers; hex head bolts; hex, cap, wing and castle nuts, all in standard sizes and threads. ALUMINUM COMPANY OF AMERICA, 618 Gulf Building, Pittsburgh 19, Pennsylvania.



FREE!

SAMPLES OF ALUMINUM FASTENERS

Samples of Alcoa Aluminum Fasteners sent free when you request them on your letterhead. Please specify type and size you prefer.

ALCOA®

ALCOA *Aluminum* FASTENERS

Foul-weather friend...

PENACOLITE® Resorcinol Adhesives

● No wood building job presents a tougher bonding problem than that shown in this picture. These laminated keels are for a fleet of 42-foot fishing vessels. The scarf and edge joints were bonded with Penacolite Resorcinol Adhesives. Here's why. Penacolite bonds withstand the stresses of high winds and beating waves, and they are not affected by fresh or salt water. Penacolite Resorcinol Adhesives keep their strength in spite of moisture, shrinking and swelling stresses, high temperatures, chemicals and fungi.

Penacolite bonds set at room temperatures (70° to 90°F.). Pressures as low as 25 p.s.i. are sufficient. With wood, the bond is stronger than the wood itself.

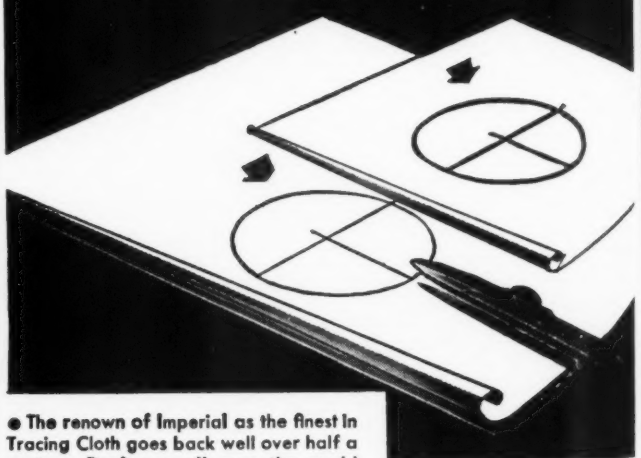
If you have a bonding problem, let Koppers Chemists help you solve it. Write for copies of Penacolite Booklets.

KOPPERS

KOPPERS COMPANY, INC.

Chemical Division, Dept. PE12, Pittsburgh 19, Pa.

TRACING CLOTH THAT DEFIES TIME



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

IMPERIAL TRACING CLOTH

Sold by Leading Stationery and Drawing Material Dealers Everywhere

HEAT GASES AND LIQUIDS

Efficiently and Economically

"Right on the Job!"

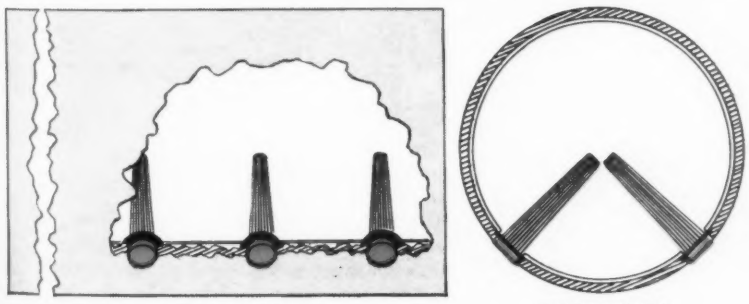
with

CHROMALOX
Electric
IMMERSION HEATERS

TMO Type Immersion Heaters are made in sizes up to 75 KW to operate in temperatures up to 800° F. and pressures up to 600 pounds.

CHROMALOX Tubular Immersion Heaters are used for heating compressed air and other gases: for super-heating steam; for heating liquids and Dowtherm, Prestone and similar heat-transfer mediums. They can be readily applied to high-temperature and high-pressure operations.

CHROMALOX Electric Immersion Heaters give you the *exact* temperatures you require and maintain these temperatures accurately. Dependable performance, economical operation, reduced spoilage are among other advantages gained by using these easy-to-install heaters.



GIANT STEAM ACCUMULATOR USING CHROMALOX IMMERSION HEATERS (SIMPLIFIED VIEW)

Twenty-four TMO Heaters of 24 KW each are used in this steam accumulator (approximately 72 feet long, 8 feet diameter) to maintain 300° F steam temperature.

This installation was worked out on the job by Chromalox Application Engineers who are always ready to help solve your heating problems.

CHROMALOX

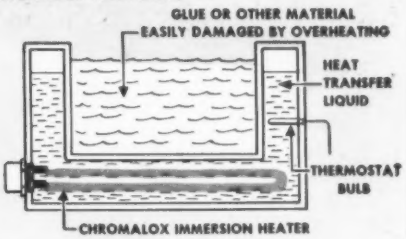
Electric Heat for Modern Industry

EDWIN L. WIEGAND CO. · 7535 Thomas Boulevard · Pittsburgh 8, Pa.

Typical Examples

of a few of the many uses for Chromalox Immersion Heaters

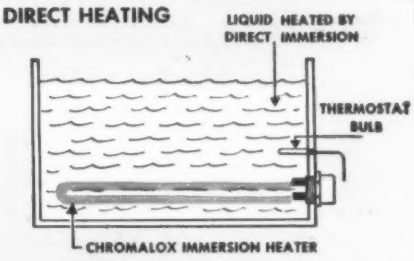
INDIRECT HEATING


GLUE OR OTHER MATERIAL EASILY DAMAGED BY OVERHEATING
HEAT TRANSFER LIQUID
THERMOSTAT BULB
CHROMALOX IMMERSION HEATER

WATER OR OIL JACKETED KETTLES

Heaters are quickly and easily mounted in kettle wall; temperatures are accurately maintained manually or by automatic control. Uniform heat transfer makes this application particularly good for liquids that must be heated slowly to prevent damage by overheating.

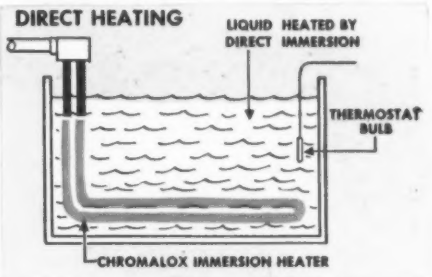
DIRECT HEATING



HEATER MOUNTED PERMANENTLY IN TANK

Chromalox Immersion Heaters are welded or bolted through tank wall. Heaters are sheathed in copper, steel or alloy—as required to defeat corrosion. Temperatures are controlled thermostatically. Heat is absorbed directly and efficiently.

DIRECT HEATING



FOR HEAVY-DUTY IMMERSION HEATING

Low-density Immersion Heaters are especially designed for high-temperature melting-pots or salt baths. Heaters have legs to raise elements above sludge accumulation. They are quickly installed and easily removed for maintenance.

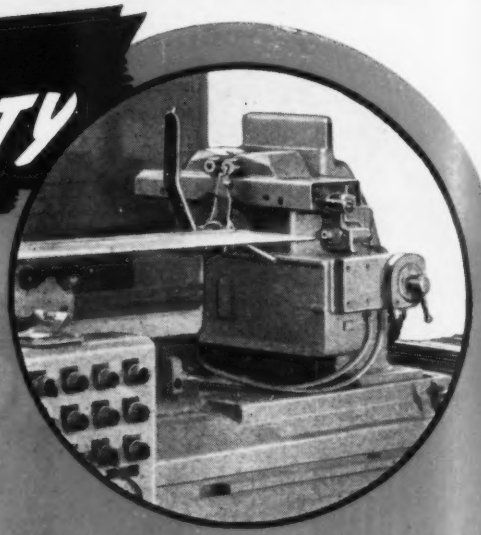
Want more Examples?

Request the fully-illustrated booklet "100 Ways to Apply Electric Heat." It contains photographs and drawings showing Chromalox Electric Heaters at work in plants throughout the United States. Write today for your copy.

IC-41

Another New GEARGRIND-

with Greater LENGTH CAPACITY



TYPE GG-10 x 48A WITH AUTOMATIC WHEEL FEED

This is a combination spline and gear grinding machine, handling both involute and square key splines and work up to 48″ long. The illustration shows it equipped with the Geargrind spline trueing device. The wheel trueing device for use with gears is shown in the insert.

If you have work within the capacity range shown below, write for complete specifications and catalog.

CAPACITY:

Takes between centers	Up to 48″
Gear diameter	¾″ R.D. to 10″ O.D.
Maximum swing	12½″
Number of teeth	4 to 120
Face width	Up to 34″
Diametral pitch	32 to 4

(For other diametral pitch requirements, consult our engineering department)

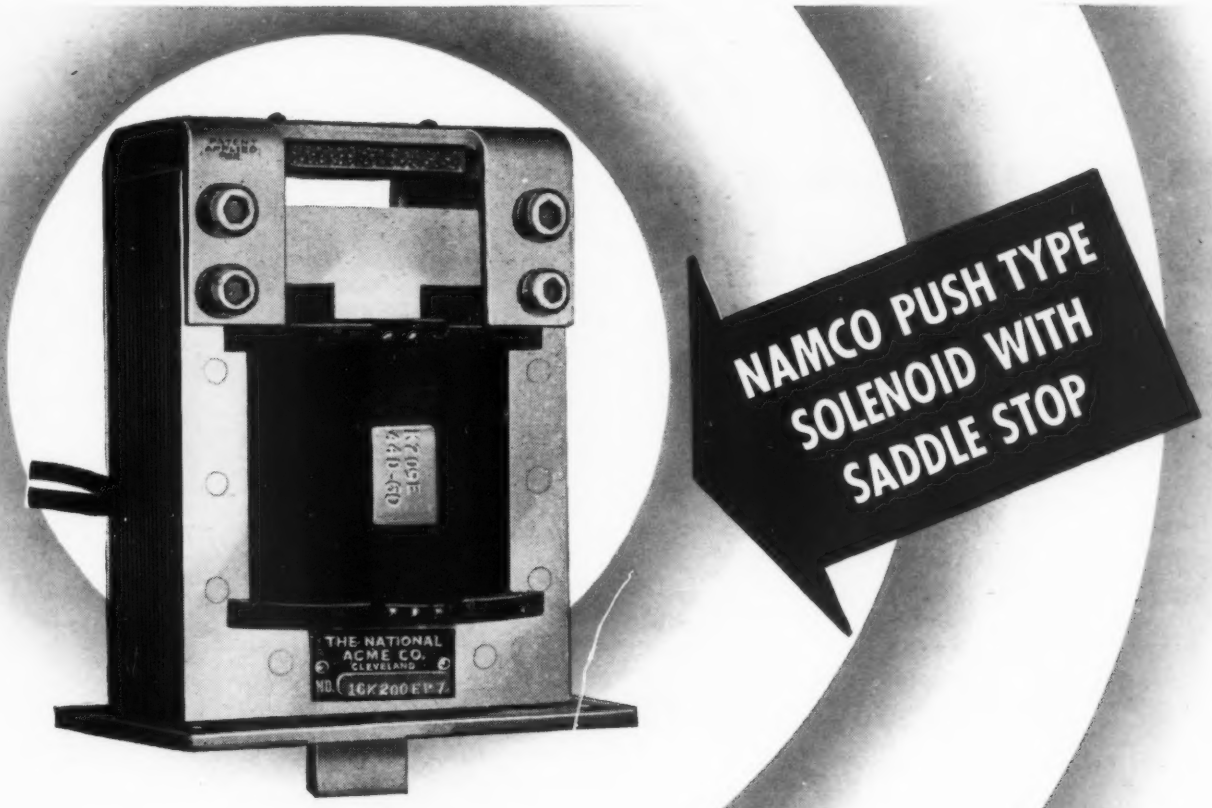
FORMED WHEEL GRINDING

There is no "distortion from heat treat" when you use the Formed Wheel Method of grinding external and internal gears, external and internal involute splines, straight splines, serrations and racks.

Geargrind Machines—in many styles and capacities—insure accuracy, fine finish and speed in production.

Catalog on Request

The GEAR GRINDING MACHINE COMPANY
DETROIT 11, MICH., U.S.A.



FOR *successful* SOLENOID OPERATION

—we engineer them to your needs

A push—or a pull—built into your machine—can save time and money—if it's specifically designed to do the job *right.*

That's where Namco "Stellite"-Welded Solenoids shine. For some applications they'll even replace fractional horsepower motors; they're built in capacities up to 25 pounds—and custom-engineered to your needs, overcoming such hazards as oil, vibration and atmospheric conditions, if these are your problems.

If you want something more in the way of solenoid service than mere shelf-stock, hit-or-miss operation (not the kind that's good enough for toys and cheap household appliances)—if you want precision and uninterrupted trouble-free action on heavy-duty production-line jobs—then you'll want the best—Namco Solenoids. For the "how" of *successful* solenoid application, consult with us.

Namco "Stellite"-Welded Solenoids are built in a variety of sizes and mountings, both push and pull types, to meet every commercial application. The complete standard range is illustrated and tabulated in Engineering Bulletin EM-46. Ask for your copy.

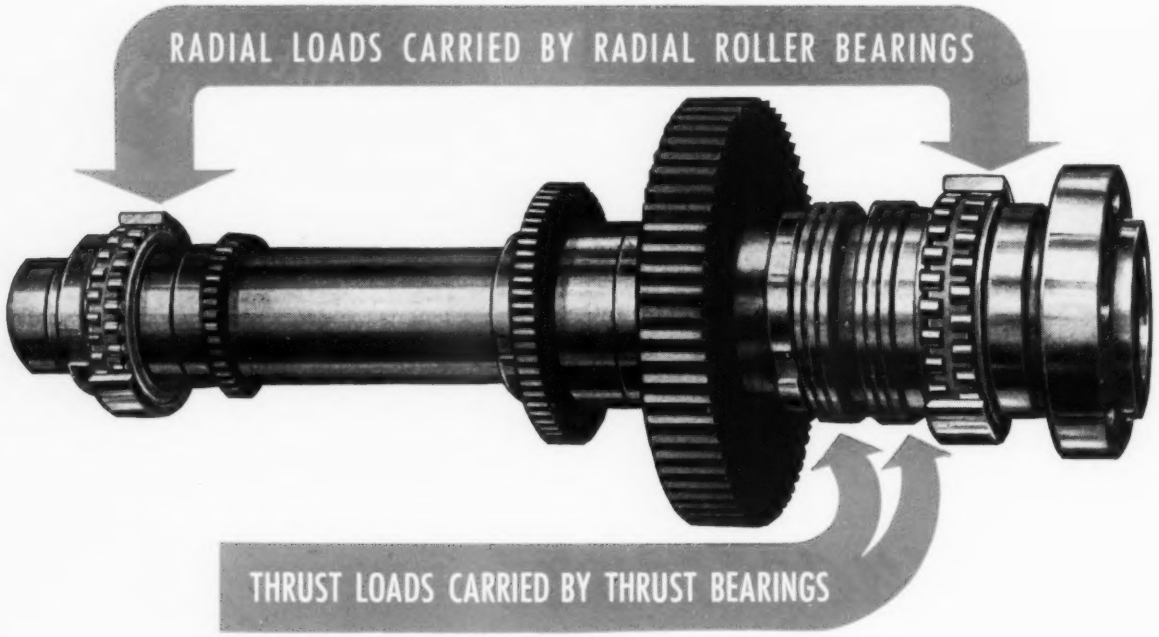
ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog • Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing

up to 500% Greater SPINDLE RIGIDITY



IDEAL DESIGN FOR HEAVY-DUTY MACHINE TOOL SPINDLES

Here is a spindle so rigid that its yield under load is as low as ⅕ that of other spindles.

SKF Double Row Cylindrical Roller Bearings are designed expressly for spindle use. The multitude of rollers in staggered arrangement, distributes the load through many radial contacts, providing great radial rigidity. Press fit of the outer ring in the housing eliminates yield at that point. Internal clearance is absorbed by means of the tapered bore of inner ring fitting upon tapered spindle seat.

SKF Thrust Bearings, the contact of the rolling elements being axial in direction, provide great axial rigidity.

Radial and axial loads being sustained by separate bearings, friction is reduced to a minimum, and operating temperatures are extremely low.

This spindle is ideal for heavy-duty cutting of hard, tough steels with tungsten carbide tools. It will handle a wide range of speeds, feeds and depths of cut without bearing adjustment.

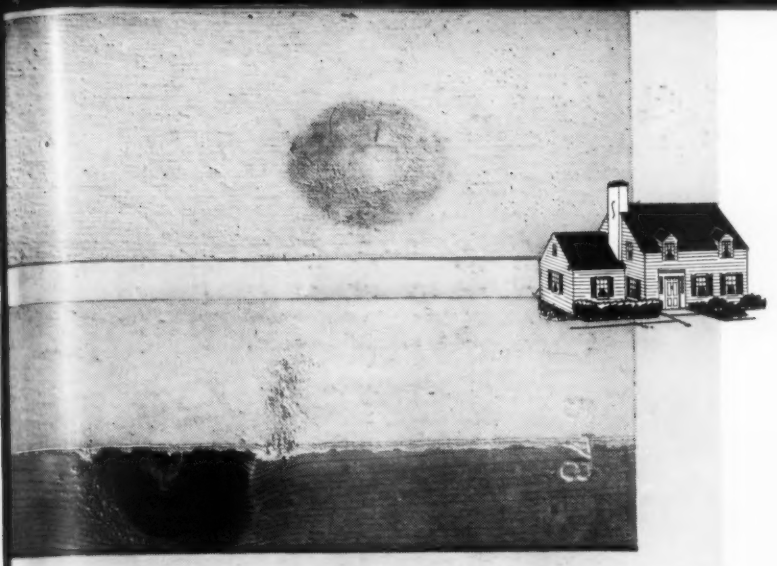
Our engineers are prepared to recommend the correct adaptation of this design to your specific requirements. 6368

SEND FOR NEW, 60-PAGE CATALOG NO. 272

SKF INDUSTRIES, INC.
PHILADELPHIA 32, PA.

SKF
BALL AND ROLLER BEARINGS

THE RIGHT BEARING FOR THE RIGHT PLACE



The end of a KNOTTY PROBLEM!

❶ Paint applied to unsealed knots soon fails (top). But a knot sealer that makes paint last on knots as long as on plain wood has been recommended by the Western Pine Association over some 600 others. It is WP-578, a practically colorless liquid based on BAKELITE Varnish BV-9700-S and VINYLITE Polyvinyl Butyral Resin XYHL. It has made millions of feet of economy grade lumber suitable for exterior siding—and its success has led to study of its usefulness for sealing plaster and other materials.

BAKELITE NEWS NO. 4

NOTES FROM BAKELITE CORPORATION ON BETTER, FASTER, LOWER COST PRODUCTION WITH "BAKELITE" PLASTICS

What! No SOAP Worries?

❷ Correct! For an added optional feature of the new Bendix "Gyromatic" Home Washer is this automatic soap injector that ends the housewife's chore of measuring soap for the laundry. Set a dial, and soap or detergent in the right amount is added to the water. The injector housing is economically molded from BAKELITE Phenolic Plastic, to resist chemicals, hot water, vibration, and torque of the driving pulley. It all adds up to long service!

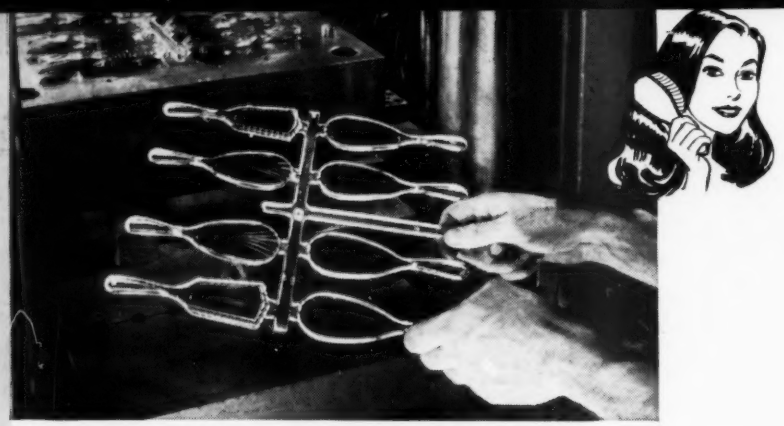
Originality Unlimited!

—that's the thrill of working with plastics!

Clear-view PACKAGING that STEPS UP sales!

❸ Here's one for the youngsters to grow on! It's a "Step-Up Set" of International's 1847 Rogers Bros. silverplate, covered by sparkling-clear BAKELITE Styrene Plastic with a richly colored, tight-fitting base of the same material. It holds baby's first spoon, a set of pieces to use when he's a little older, and one for use when he's really mastered his table manners. The permanently attractive case is easily cleaned with a damp cloth. It is moisture- and chemical resistant and dimensionally stable—advantages that point up the usefulness of this plastic for hundreds of new packaging uses.

PLEASE TURN THE PAGE

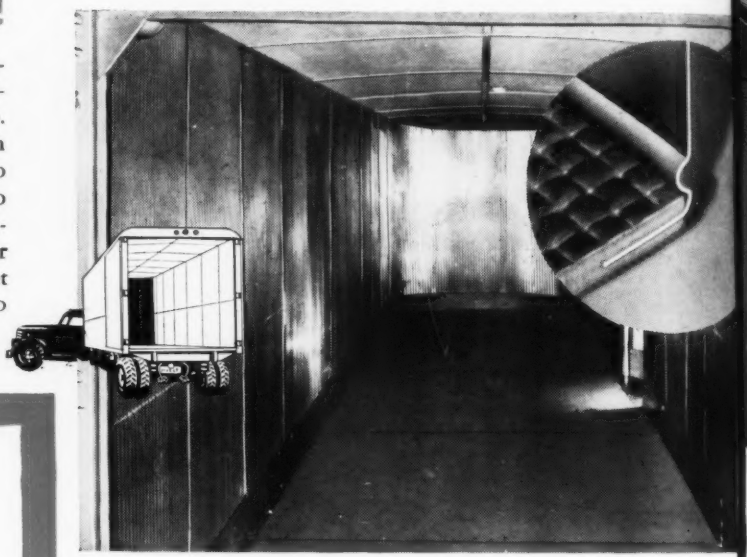


There's MILEAGE in this truck FLOORING!

5 And non-skid mileage at that! It's called "Consoweld" laminated plastic flooring. The Plastics Division of Consolidated Water, Power and Paper Co. fabricates it from selected paper stocks bonded with BAKELITE Phenolic Varnishes hydraulically pressed to form a dense, hard, rigid sheet. The flooring is easy to install and its toughness and wear resistance cut maintenance costs. Its non-skid surface makes loading safer and helps prevent dangerous load shifting. Inset shows how a strip of stainless steel is molded in to provide a water-tight wall joint.

BEAUTY injection-molded into BRUSHES!

4 Yes, luxurious beauty that is inherent in BAKELITE Styrene Plastic! Empire Brush Works, Inc., now molds the backs and handles for its exquisite personal brushes from this versatile plastic. It is not only beautiful, but economical and easy to mold to intricate shapes. It is strong, resistant to water, easy to clean, warm to the touch. Extrusion-molded in crystal and transparent pink and blue, the brushes are at home on the most luxurious dressing table.



Bakelite

TRADE-MARK

PLASTICS

BAKELITE CORPORATION

BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation UCC
30 East 42nd Street, New York 17, N. Y.

Every Designer Should Know About The Expanding Family of Plastics

Check coupon below for information on specific subjects illustrated. For general information write for copy of Booklet G-8, "A Simplified Guide to BAKELITE and VINYLITE Plastics."

BAKELITE CORPORATION, Department 15
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- ☐ 2. Phenolic Molding Plastics
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- ☐ 4. Molded Styrene Plastics
- ☐ 5. Plastic Truck Flooring
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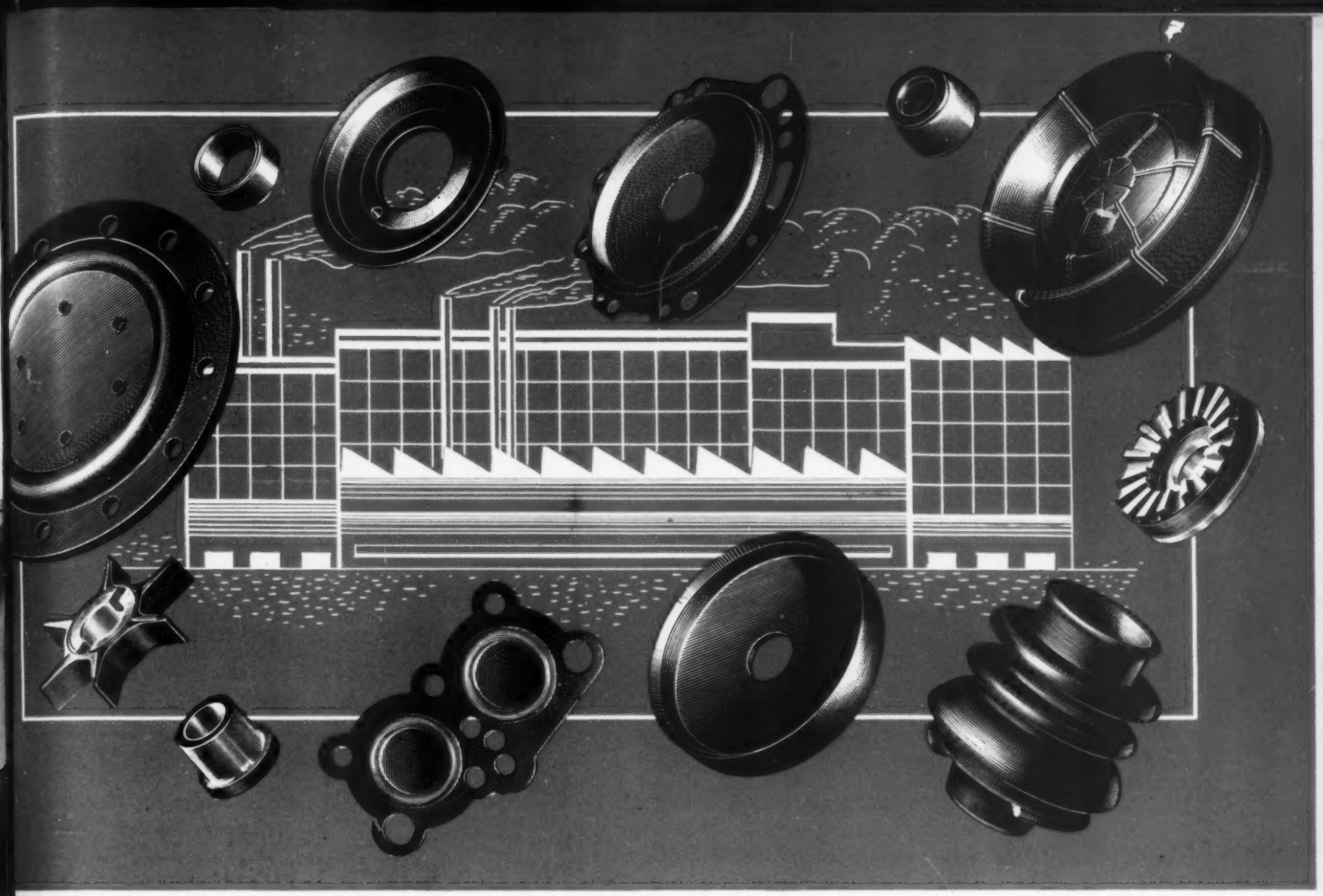
TELEVISION Innovation . . . Admiral's PLASTIC Cabinet!

6 Yes, in a single, deep draw of 16¾", the cabinet of Admiral's new table-model television set—grill front, top, bottom, and sides—is rapidly molded in one piece from general-purpose BAKELITE Phenolic Plastic. Production economy is the first advantage. But added plus values are: Highly marketable beauty of design and finish, dimensional stability, resistance to moisture, and easy cleanability. And the excellent insulating properties of BAKELITE Phenolic Plastics make it possible to incorporate electrical and mechanical functions in a one-piece structure. The molder is Molded Products Corp.



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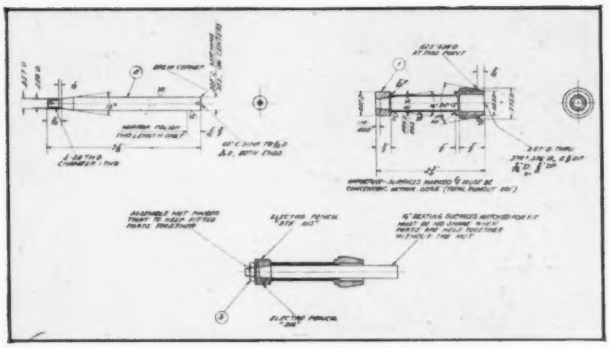

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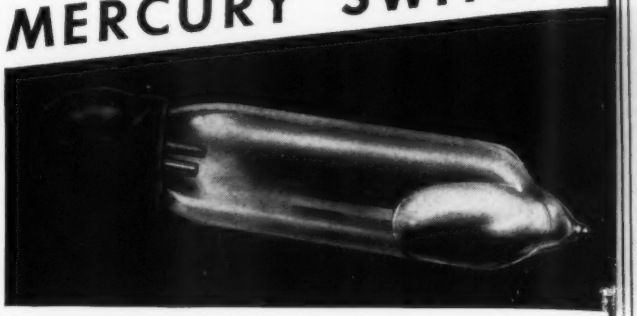

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- POSITIVE CONTACT . . . Honeywell switches are sealed against dust, gases, corrosion. No danger of arcing or fouled points.
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Only a minimum of power or energy is required to operate Honeywell Mercury Switches. Some models are actuated by a tilt of less than one degree. And, this ease of actuation is an important advantage because it often provides the opportunity for new design improvements, simplified assemblies and greater operating efficiency.

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Should Interest You

. . . even if you don't make Garden Tractors

A Mercury Clutch, installed on the gasoline engine powering a garden tractor, makes starting easier and permits no-load idling. Just one application out of hundreds, from Air Conditioning to Washing Machines. On electric motors Mercury Clutches reduce starting current demand and afford positive protection against damage to motors, blown fuses, flickering lights, and fire hazards. Write for your copy of the Mercury Catalog and Selection Chart.

Mercury Clutch Division
AUTOMATIC STEEL PRODUCTS, INC.
CANTON 6, OHIO

"He's figuring what we *SAVE* by using N-B-M #397 SILVER BABBITT!"

First he figured the performance based on service records of bearing-lining metals and then he figured the first-costs...N-B-M #397 Silver Babbitt won on both counts.

If you're responsible for cutting costs in your plant or product, find out about N-B-M #397 Silver Babbitt. This comparatively recent development has already been accepted as standard procedure by engineers interested in long, trouble-free bearing service combined with lower costs. N-B-M Silver Babbitt gives you all the desirable performance of tin-base babbitt *at considerably less cost.* Note these economy and performance characteristics of N-B-M Silver Babbitt:

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- Costs 30% to 40% less than tin-base babbitt

Plant Operating Engineers and Product Designers: Write for N-B-M Silver Babbitt Folder containing physical properties and Engineering Briefs. Quotations on request.

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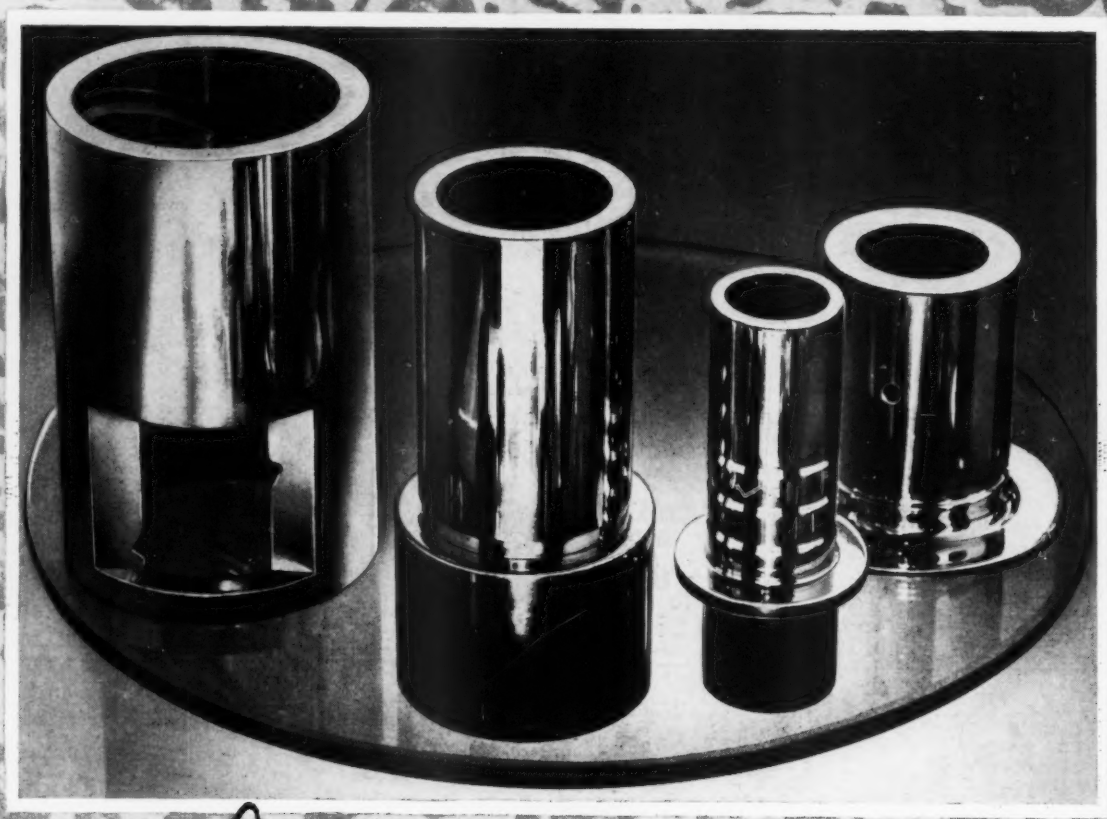
AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION

4930 Manchester Avenue • St. Louis 10, Mo.



If noise is one of your problems, consider the sleeve bearing. The oil film operates silently and insulates against noise transmission. Bunting engineers will gladly discuss specific applications with you. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in principal cities.

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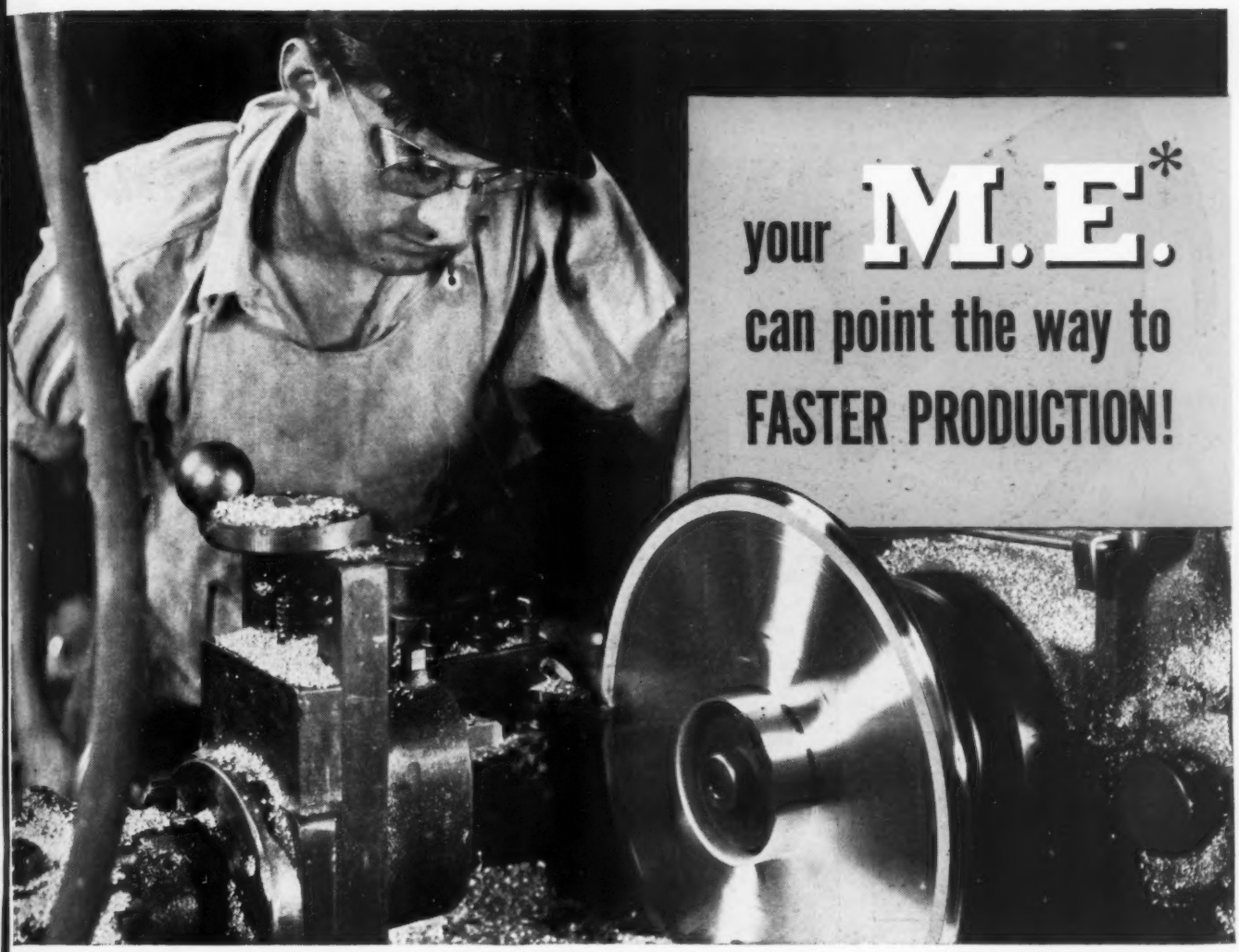
BRONZE BEARINGS ☆ BUSHINGS ☆ PRECISION BRONZE BARS

31



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The magnesium castings he designs will machine fast and easily to a superlative finish, in a fraction of the time other production metals require. Your first cut can be your finish cut.

Magnesium-light products have new sales appeal. And easier handling, when they weigh only a fourth as much as iron. No waiting for trucking or hoisting. Just hand them along.

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*M.E., in this case, means Magnesium Enthusiast, and Mechanical Engineer as well. He's probably young, may have joined you since the war. He knows from experience the powerful appeal of American Magnesium parts: castings 75% lighter than iron, 35% lighter than aluminum. He knows the economics of magnesium which make his recommendations practical.

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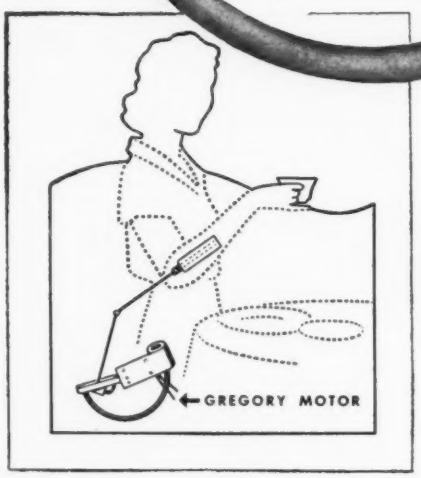
constant motion . . . but NO SWITCHING TROUBLE!



Above: Diagrammatic sketch shows application of simplified display animation provided by electro-pendulum motors of Gregory Motors, Inc., Brooklyn, N. Y.

WITH THE

HONEYWELL

MERCURY SWITCH

A foremost feature of the new Gregory Electro-Pendulum Motor for moving displays is carefree, long-run service with safety. Operating at a rate up to two cycles per second, each cycle requires a full "make" and "break" switching action. Twice every second, hour after hour, day after day the action is continuous. This demands a switch just as dependable, just as long-lived as every other element in the Gregory Motor.

To meet this rugged requirement, Gregory designers selected Honeywell Mercury Switches. Light and compact, Honeywell switches are easily adapted to small spaces and unusual mountings. Only a minimum of energy is required for actuation and some models are operated by a tilt of less than one degree. Fouled points cannot occur because contact is made within a vapor-proof glass tube. And with fewer parts, no complicated mechanisms or assemblies, dependable, trouble-free performance is assured.

For your switching needs, Honeywell Mercury Switches may offer greater latitude in design, improved performance or greater economy. Write for the Mercury Switch catalog or the services of a Honeywell-Brown engineer.

Remember these ADVANTAGES

- Ease of Actuation . . . balanced, and light in weight, Con-tac-tors operate with little energy.
- Positive Contact . . . Honeywell switches are sealed against dust, gases, corrosion. No danger of arcing or fouled points.
- Long life . . . fewer moving parts, simplified assembly means dependable, economical operation.
- Variety of Types . . . means wide range of applications, increased design opportunities.

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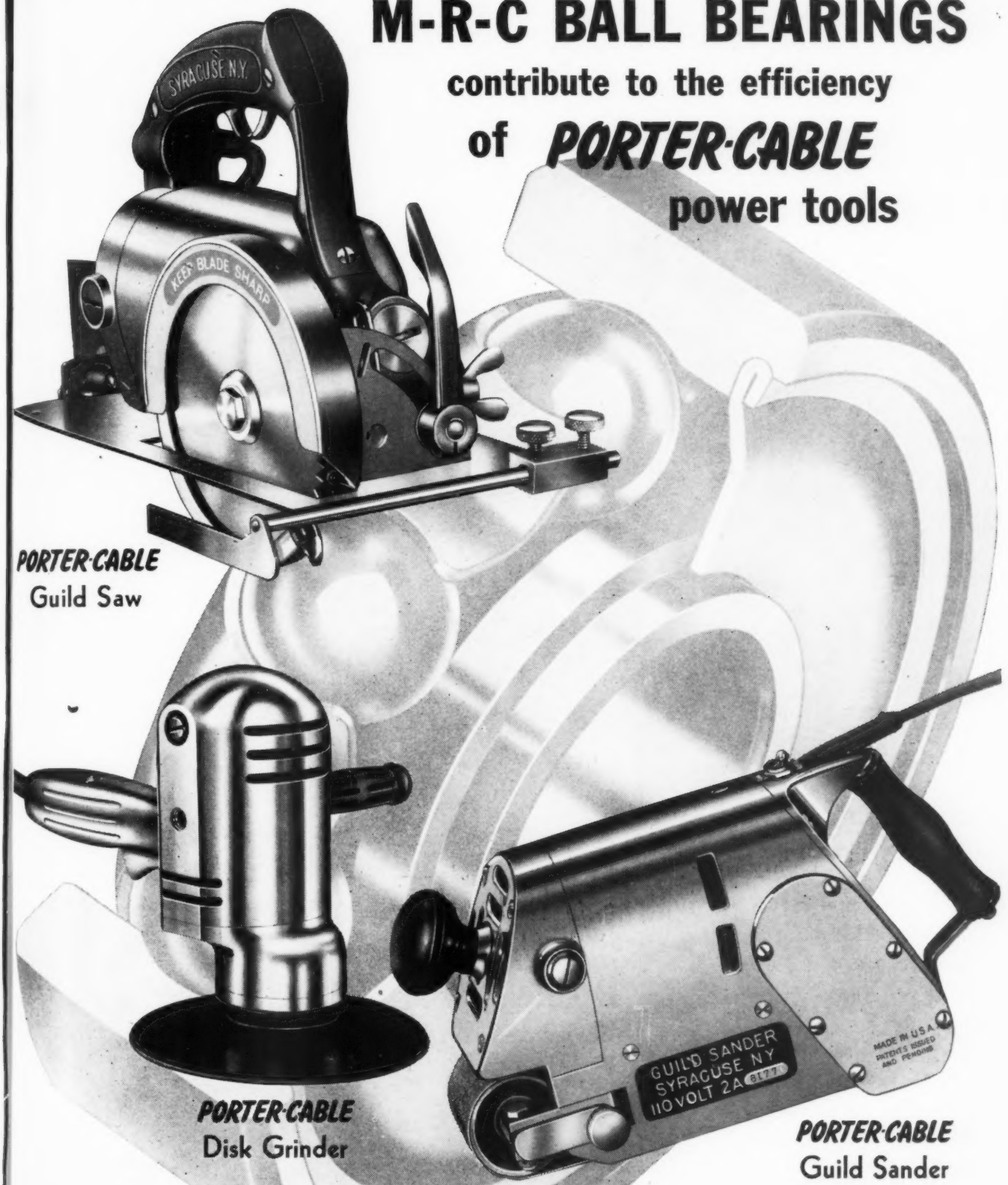
contribute to the efficiency

of PORTER-CABLE

power tools



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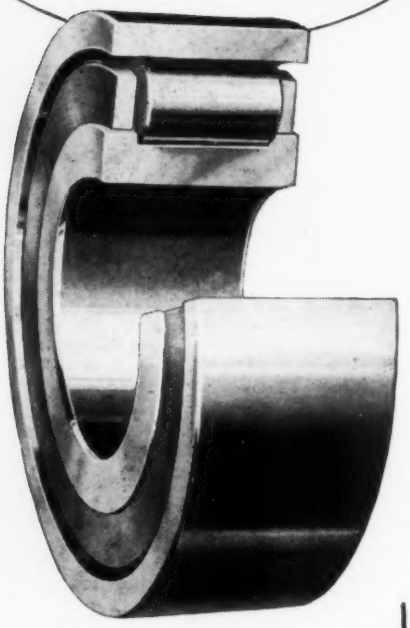
Install Them and Forget Them!

AMERICAN

RADIAL

Roller Bearings



AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.

Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.

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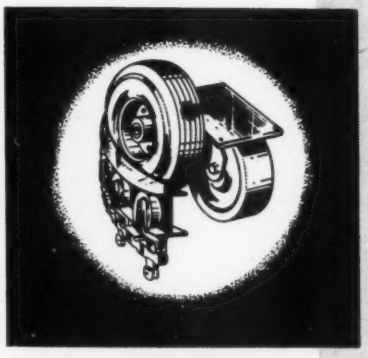
FOR LONG SERVICE FREE LIFE . . .



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You get premium quality without paying a premium price when you use Skinner 4 Point Filters. A specially designed phenolic-impregnated resin element far outperforms any "screen strainer". This Skinner element is non-collapsible and needs no reinforcement. It can be used to filter either air or liquids. Skinner will be glad to work with you, helping to increase your product's efficiency and reduce wear. For specific information on *your* particular filtration problem, WRITE DIRECT TO:

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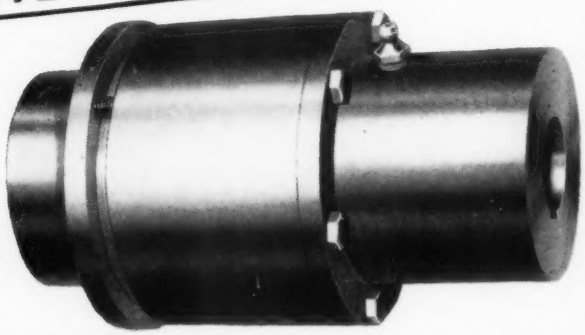
KINNEY "Multi-Disc"

does a man-sized job WITHOUT THE MAN!



Kinney presents the "Multi-Disc"—an entirely new overrunning clutch totally free from troublesome "drag". Unique wear-free mechanism automatically and positively shifts the clutch but does not transmit power. Shifting action allows gradual pick-up whether load is light or heavy. Drive is through multiple plates of steel and sintered bronze: clutch capacity is easily determined, permitting installation of exactly the right "Multi-Disc" for each job. Capacities up to 30 HP per 100 RPM; beyond 30 HP on special quotation.

The line of Kinney Clutches is complete — Interchange, Over-running, Dry Plate, Oil Type, and Worrall, for every need of Industry. *Let us know your requirements.*

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360° CLOSURE

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The Standard X Washer is an efficient, economical locking device. It provides quick, positive assembly . . . 360° closure to support greater thrust load . . . fast, easy removal . . . simplified service or repair. No vibration can shake it loose.

Standard X Washers are available for pin diameters from 7/32" to 17/32". For complete specifications write for Bulletin 26.

Standard

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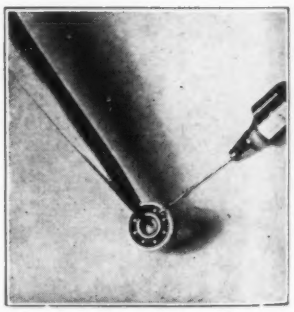
MICRO

The *Ground* Miniature BALL BEARING



New Hampshire MICRO Ball Bearings are the only *fully ground* bearings in the U. S. under 3/8" OD.

Radial, Radial - thrust, Self Aligning and Pivot Ball Bearings, 5/32" to 3/8" OD.

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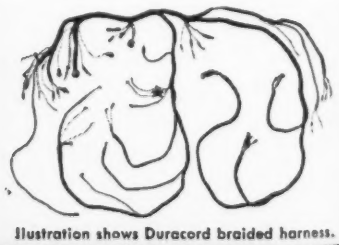

Illustration shows Duracord braided harness.

Our specialized methods and equipment enable us to furnish complete, custom-designed wiring harnesses ready for installation at less cost than you can do the job in your own plant.

We can furnish any type required: wrapped, braided, shielded, laced or steel conduit; moulded rubber, plastic or ceramic fittings. Send for literature. 2

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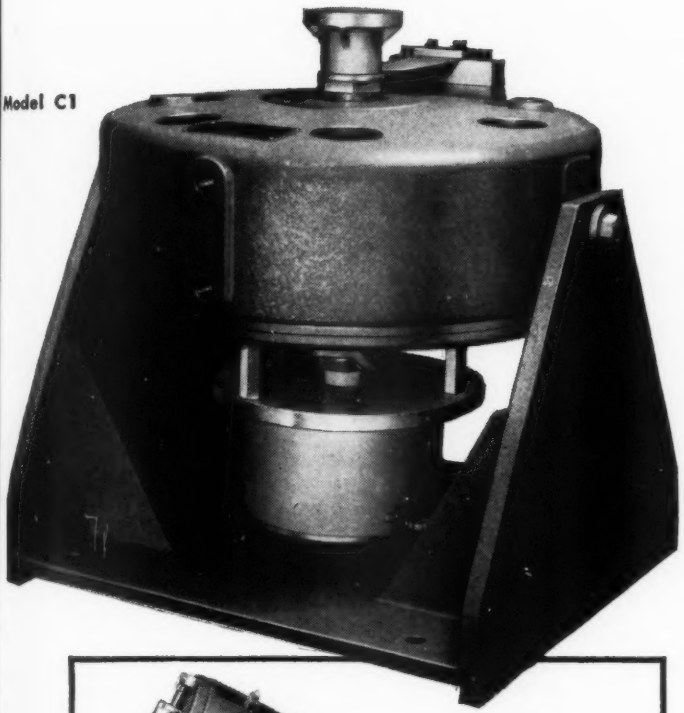
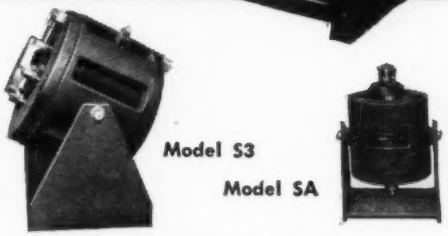
Product faults found in minutes with MB vibration exciters!



Model C1



Model S3

Model SA

Note that MB Exciters can be swung to any convenient angle on the trunnion mounting.

SOME TIME AGO, a large automotive manufacturer was attempting to learn whether gas tanks could be strengthened.

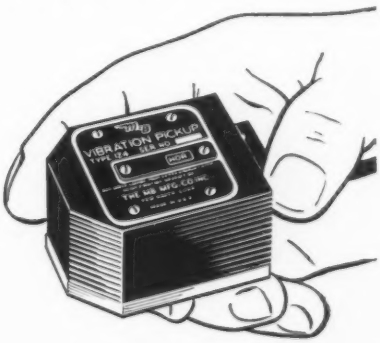
They first used a mechanical shaker on a test tank in an attempt to discover possible trouble—but days went by without signs of failure. However, when an MB Exciter was attached, the tank was vibrated to destruction in a matter of *minutes!* A repeat test produced a similar failure. Based on the *visual* evidence, *which eliminated the need for any dynamic computations,* the tank was redesigned, and it was made not only *stronger,* but materially *lighter*—cutting costs as well as saving steel.

In another case, where one manufacturer's headlight bulbs were failing in great numbers, an MB Exciter fixed the blame at once—on the filament supporting arm, which was resonating at a frequency within the operating range of the car.

These cases illustrate a technique of testing that you'll find increasingly valuable as experience shows you new applications for this product improver. MB vibration exciters are now being used by many of the country's largest companies—for fatigue testing, for location of noise sources, for determining the vibratory response of products—*and the corrective measures.*

Would you like to know more about how to use this shaker in your own work? An MB engineer will be glad to give you the benefits of our specialized vibration experience.

If your product has any vibration at all— this MB VIBRATION PICKUP will detect it!



There's no practical lower limit on the amplitude of vibration you can detect with the MB Vibration Pickup—it's that sensitive! And there's no engine it can't be used on — it's that durable under high-powered pulsations!

It is a velocity-type pickup, electrically damped, with a range of 5 to 1000 c.p.s. and usable in any position. When the pickup's electrical output is fed to standard voltage measuring equipment, it can be used to check products for operating smoothness and for quality-control.

WRITE FOR FREE BULLETINS

Ask for bulletin "Vibration Testing Technique" which describes how MB Exciters are used. And Bulletin 124A will give you more details on Pickup. Write Dep't. D6.

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For Sustained ACCURACY of DIAPHRAGMS and other spring parts

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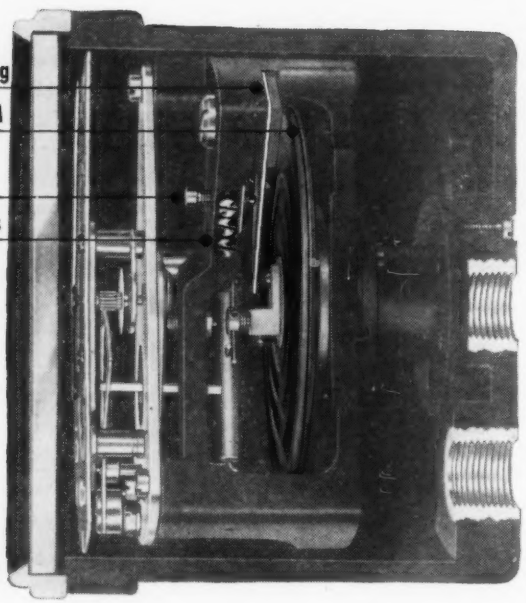

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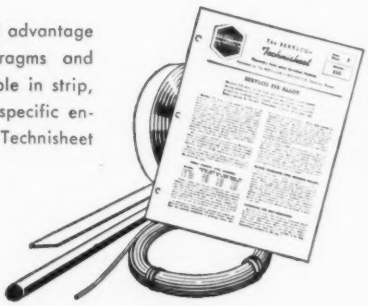
Here is an instance of the use of heat-treatable Berylco 25S, of which U. S. Gauge says, ". . . probably the most critical and exacting application to which any metal is subjected." Beryllium-copper alone meets the manufacturer's requirements of minimum drift, low hysteresis, elimination of zero shift, uniformly low grain size and extreme tolerance control on thickness. Moderately cold-worked BERYLCO 25S is readily formed, and with heat-treatment attains the highest tensile strength and hardness of any non-ferrous material. In addition, this alloy offers excellent resistance to wear and corrosion.

Use BERYLCO 25S to good advantage in the design of diaphragms and other spring parts. Available in strip, rod, and wire forms. For specific engineering data, write for Technisheet No. 2.



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Solenoid STAINLESS STEEL *Valves*

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★ Standard pressure range, 5 to 250 psi
★ Dimensions 2¾" high x 1⅝" dia.
★ Impregnated coils withstand moisture and condensation
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★ Also many special valves for handling pressures from 5 to 850 psi

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Learning Your Clutch Needs

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Analysing the Problem

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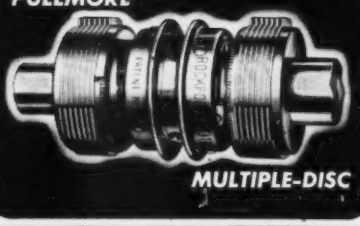

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Planning Production

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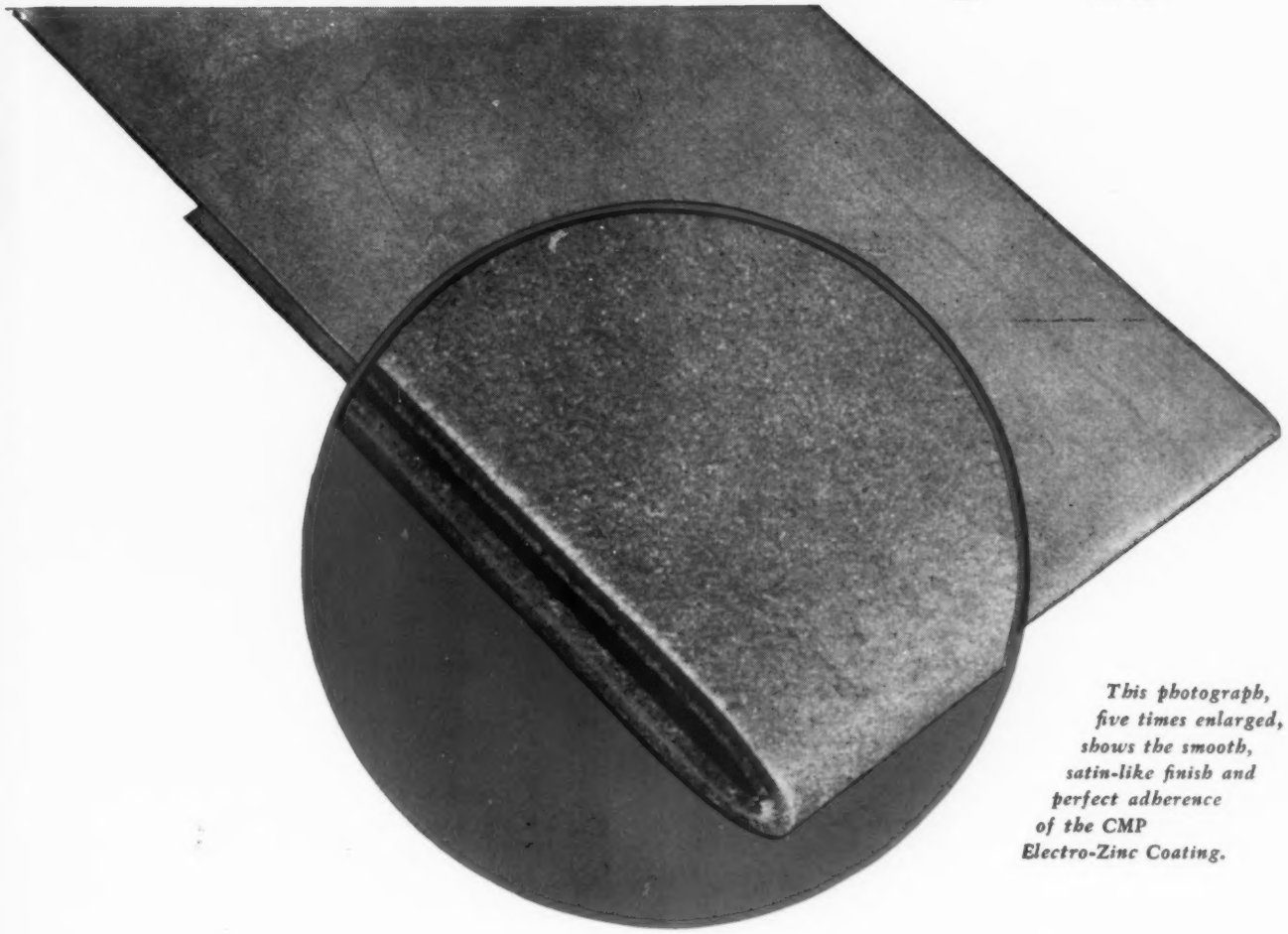

This photograph, five times enlarged, shows the smooth, satin-like finish and perfect adherence of the CMP Electro-Zinc Coating.

Electro-Zinc-Coated Strip Steel

A CMP THINSTEEL TRADE MARK Product

The characteristics of uniformity and accuracy to gauge always identified with CMP's uncoated light gauge cold rolled strip steel products are now also available where the protective advantages of a zinc-coat are desirable. The electro-plating of zinc on CMP Thinsteel produces a corrosion resistant strip which can be submitted to punishing fabricating operations such as deep drawing or sharp bending without flaking or injury to the coating. And if the fabricated product is to be painted, you can specify a phosphate-treated zinc-coat which provides the base to which paint will best adhere. We are confident you will find electro-zinc coated CMP Thinsteel a superior product and we will be glad to furnish samples to support the claims we make for it.

CMP STRIP STEEL — PRECISION COLD ROLLED

the Cold Metal Products co.

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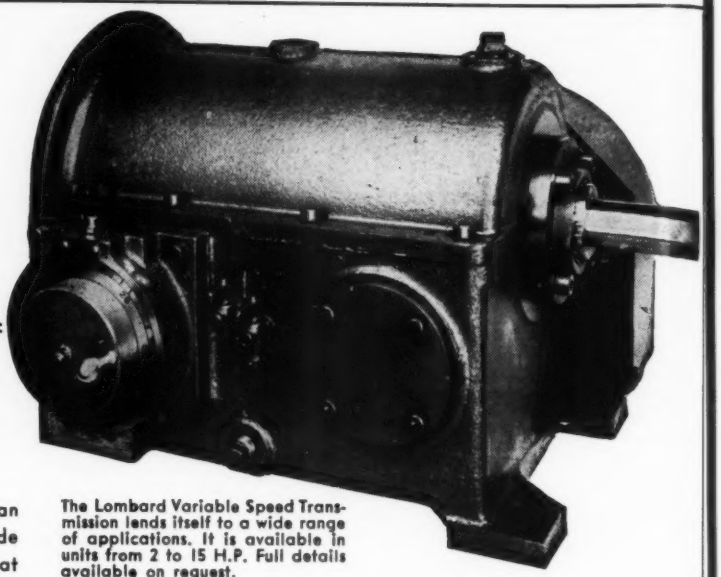
THE NEW LOMBARD TRANSMISSION



The Lombard Variable Speed Transmission lends itself to a wide range of applications. It is available in units from 2 to 15 H.P. Full details available on request.

. . . for applications requiring infinite variation in speeds

By incorporating the Lombard Variable Speed Reducer as an integral part of equipment, it is possible to provide a wide range of easily controlled useful speeds. Design is such that a speed range of greater than 20 to 1 can be obtained with a minimum speed approximating zero.

Power is transmitted in a straight line from input to output shafts, thereby assuring convenient application. A planetary speed reducing unit combined with the output shaft and mounted in a steel cage provides great rigidity and assures perfect alignment of gearing. All gears are enclosed and run in oil.

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WATSON-FLAGG MACHINE COMPANY, Inc.

Paterson, New Jersey

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The Viking Pump Company is represented by a nation-wide sales and service organization in key cities from coast to coast . . . from Canada to the Gulf. Is your pumping installation operation at high efficiency? Do you have a pump maintenance problem? Do you have a new pumping application? Write or call the Viking representative nearest your plant for service.

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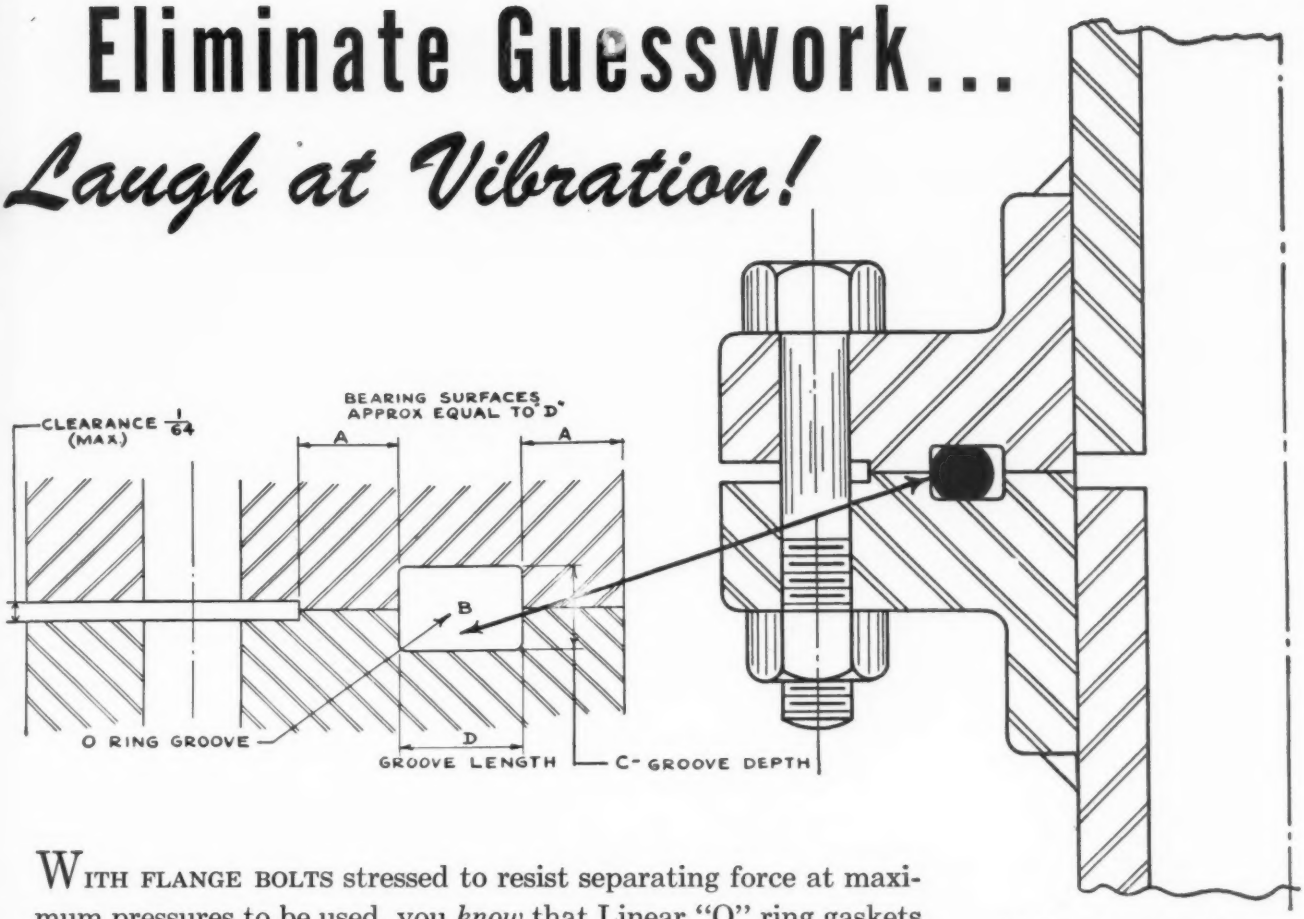
Laugh at Vibration!



"O" ring gasket for flange fittings. Groove detail shows use of the gasket.

WITH FLANGE BOLTS stressed to resist separating force at maximum pressures to be used, you *know* that Linear "O" ring gaskets will make a positive liquid or gas-tight seal. The only requirement is to maintain metal-to-metal contact between the flanges.

No more checking or periodic tightening of bolts is necessary, for once a Linear "O" ring is installed, its sealing effectiveness is unimpaired no matter how much your line vibrates!

No more costly shutdowns and repairs because of a sudden gasket blow-out. With metal-to-metal contact maintained, Linear "O" ring gaskets will seal against an unlimited pressure range. And frequent replacement is unnecessary since over-tightening cannot damage Linear "O" ring gaskets.

Available in standard sizes from ⅛" to 15½" ID and in special sizes as required, Linear "O" ring gaskets are moulded of natural or synthetic rubber compounds adaptable to a wide range of temperatures, gases and liquids. Linear engineering experience is at your disposal. May we serve you?

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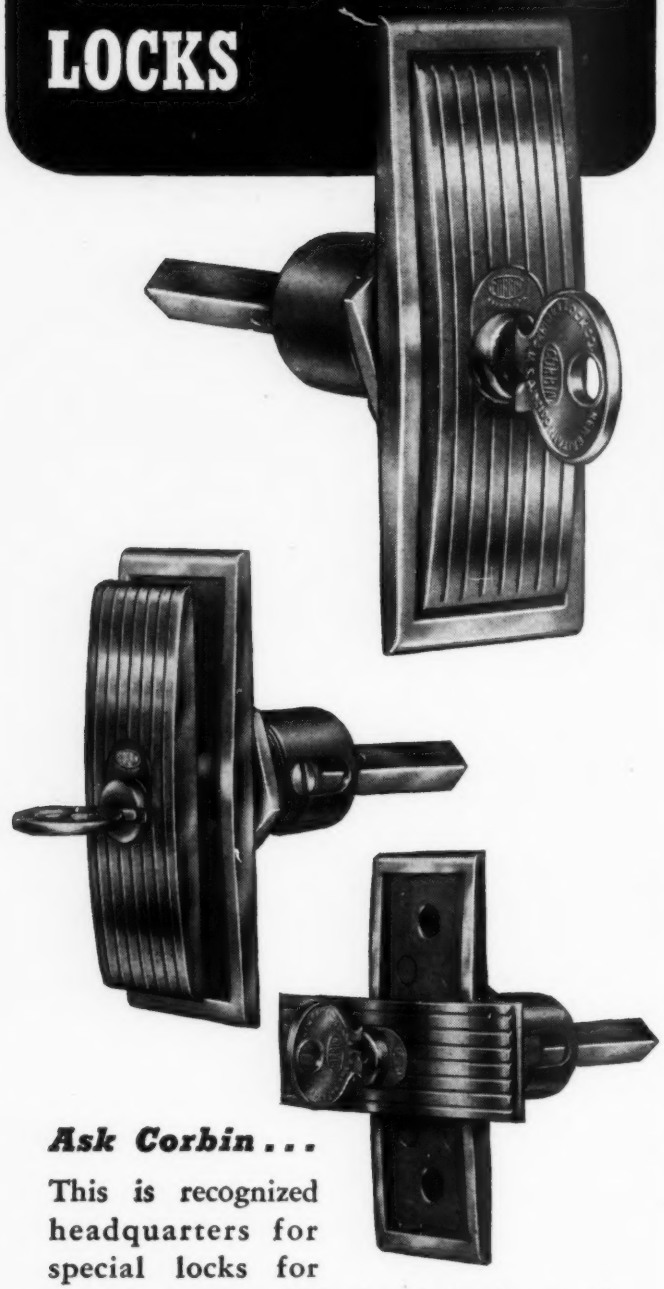

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This is recognized headquarters for special locks for special purposes. Whether it be for vending machines or any unusual application, ask Corbin engineers. Your inquiries will be welcome.

Corbin Cabinet Lock
Division
THE AMERICAN HARDWARE CORPORATION
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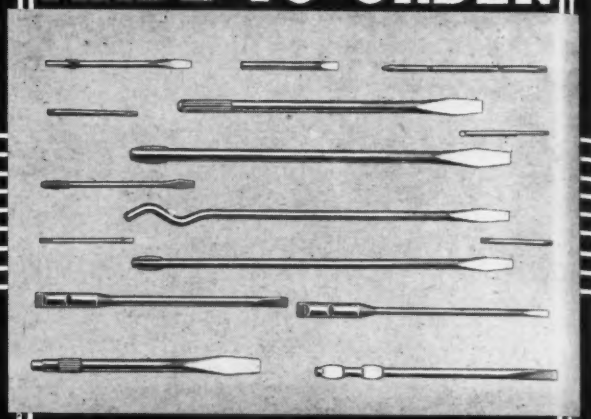

Screw driver blades to order for assembly in any type of handle, wooden, composition or plastic.

Points in either keystone or cabinet type. Edge of point carefully made and of uniform thickness.

Shanks are winged, fluted, formed or milled, as shown.

Blades furnished in plain finish, blued or nickle plated.

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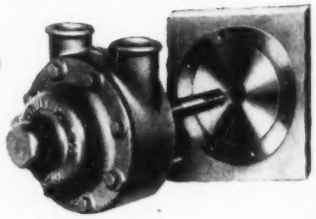
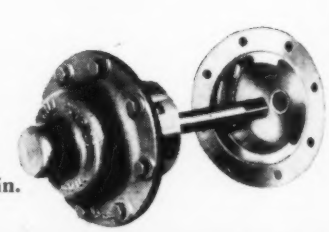
Tuthill Stripped Pumps can be built directly into the design of the machine—saving space, reducing costs and improving appearance. Two types: Model S, without supporting bracket; Model SA, with pumping elements only. Built in capacities up to 200 g.p.m. to meet requirements in lubrication, coolant, hydraulic and liquid transfer service. Also available in automatic reversing type. Write for Tuthill Stripped Pump bulletin.





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✓ machinability

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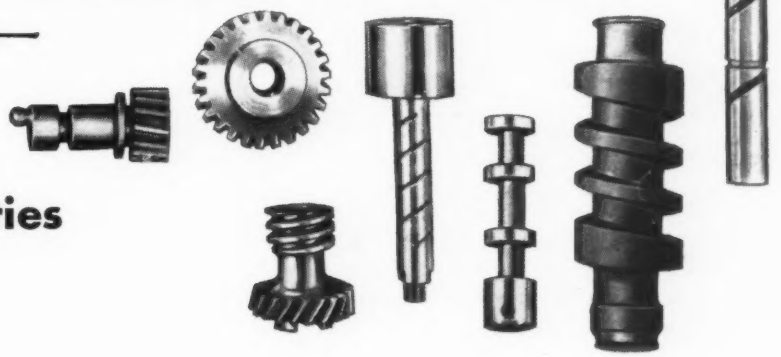

There's more to J&L Jalcase Steel than a grade number. That's why, if you want the best, you must specify "J&L JALCASE."

- It is the *original*, free-machining, open-hearth steel.
- It still is the outstanding steel in its class today.
- Its machining properties closely approach those of Bessemer steel.
- It machines with a fine finish.
- It is easy to heat treat by conventional and high-speed induction methods.
- It lengthens tool life.
- It reduces production costs.

Jalcase is available in a range of grades to suit a wide variety of applications. It is supplied as cold-drawn or cold-drawn-with-metallurgical-processing, which includes special tempering treatments. Thus many parts made of this material may need no further heat treatment after machining.

Typical Jalcase analyses are found in the A.I.S.I. 1100 series wherein the manganese content is 1.00% to 1.65%, such as in Grades C-1117 through C-1144.

Let us send you complete information on J&L Jalcase—the *modern* free-cutting steel. Write to: Jones & Laughlin Steel Corporation, 409 Jones & Laughlin Building, Pittsburgh 30, Pa.

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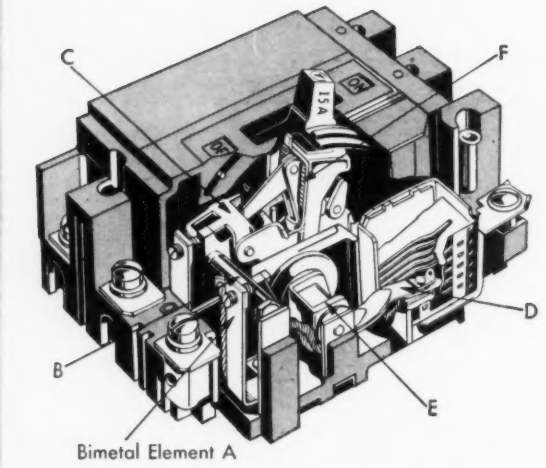
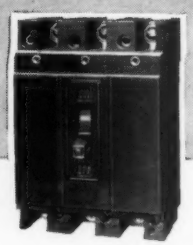
AMERICA'S FOREMOST PRODUCER OF FREE-CUTTING, QUALITY-CONTROLLED STEELS

CHACE BIMETAL . . .



Safety Sentinel in the TRUMBULL "AT" BREAKER



No. 22 — A product of Trumbull Electric Mfg. Co., Plainville, Conn.

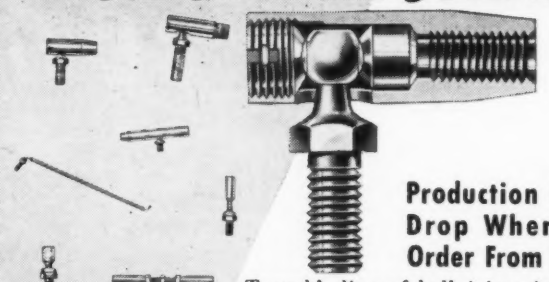
In Type "AT" Circuit Breaker, manufactured by the Trumbull Electric Manufacturing Company, is another typical use of the temperature responsive qualities of Chace Thermostatic Bimetal as the overload element. Of the "quick make-and-break" type, it is entirely trip-free, cannot be held closed against an overload—and embodies an improved structure for the quenching and dissolution of arc through a series of steel baffles mounted between insulating plates.

When an overload or short circuit occurs, the heated thermostatic bimetal element A in moving, presses against the tripping bar B, springing the latch C. The three contact arms D, fixed to shaft E of the toggle mechanism F, spring up, breaking the circuit. Thus an overload opens the entire breaker, providing complete protection for lines or equipment.

This illustrates but one of the many applications of Chace Thermostatic Bimetal as the actuating element for temperature responsive devices. Why not submit your own problems for a thorough analysis by our engineering department?

W. M. CHACE CO.
Manufacturers of Thermostatic Bimetals
1607 BEARD AVE. • DETROIT 9, MICH.

Tourek Ball Joints



Production Costs Drop When You Order From Stock

Tourek's line of ball joints includes 12 standard types in 54 sizes . . . This wide range of selection frequently enables manufacturers to specify an assembly directly from stock to meet exact requirements, thus effecting a saving in production costs and eliminating delivery schedule problems.

When special ball joint assemblies or precision screw machine products are necessary to meet requirements for new applications, Tourek's designing and manufacturing experience provides a source of valuable assistance.

Write for Tourek's 16-page ball joint catalog—it contains complete specifications on standard types and sizes, as well as data on special types.

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ESTABLISHED 1920
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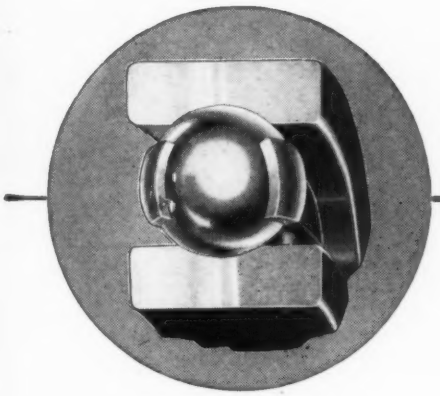
YOU CAN SEE THE DIFFERENCE

IN HOOVER HONED RACEWAYS

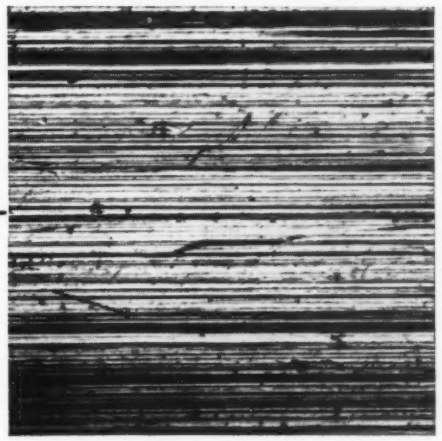
The photographs reproduced at the right are magnified one hundred times, so that you can see the difference between ground, polished and honed raceways. Hoover is America's only ball bearing with honed raceways. The process and the special machines for the honing operation, are exclusive, patented, Hoover developments. Hoover honing goes far beyond grinding and polishing to produce a surface that represents the closest approach to absolute perfection obtainable on a commercial basis.



Honed Raceway Features

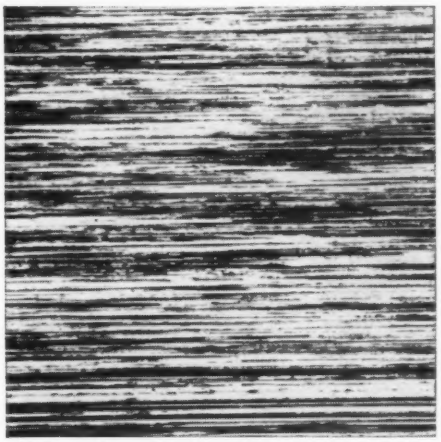
Summed up Hoover honing provides the following results . . .

1. Extreme quietness.
2. Increased load capacity.
3. Extended life.
4. Reduced end play (axial displacement).
5. Reduced radial displacement.
6. Permanence of fit up.
7. Increased resistance to Brinneling.
8. Uniformity of fit up.
9. Freedom from vibration.
10. Perfection of dynamic balance.



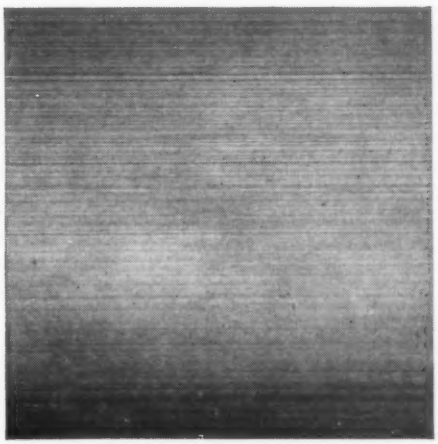
GROUND RACEWAY SURFACE
(Photographed at 100 Magnifications)

This precision ground surface is satisfactory for many types of precision products and for low-speed thrust bearings. Not suitable for high speed radial bearings demanding smoothness, quietness, long life and high load capacity.



POLISHED RACEWAY SURFACE
(Photographed at 100 Magnifications)

Adding polishing operation improves on ground surface. But increased smoothness and quietness is achieved at expense of shortening bearing life and decreasing load capacity because polishing does not permit raceway radius to be held within sufficiently close precision limits to insure uniformity.



HONED RACEWAY SURFACE
(Photographed at 100 Magnifications)

Photo-micrograph illustrates how cuts and scratches resulting from grinding and polishing are reduced to practically non-existence by Hoover honing process. This patented Hoover process achieves bearings equal to super-fine laboratory specimens, at a price you can afford to pay.

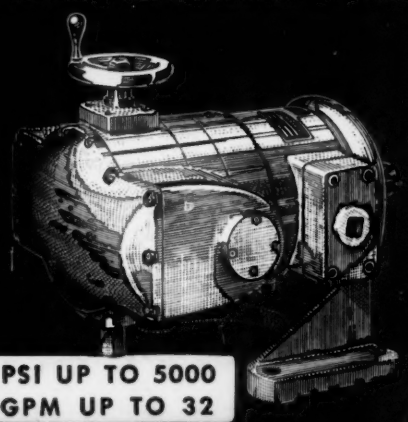
THE ARISTOCRAT OF BEARINGS

HOOVER "AMERICA'S ONLY BALL BEARING WITH HONED RACEWAYS"
HOOVER BALL AND BEARING CO., ANN ARBOR, MICHIGAN

Just Compare

Denison's Variable-Volume HydrOlLic Pumps

WITH ANY OTHER MAKE OF PUMP



PSI UP TO 5000
GPM UP TO 32

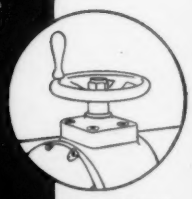
COMPARE COST

COMPARE CAPACITY

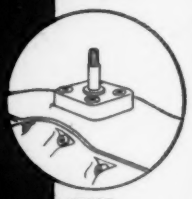
COMPARE QUIETNESS

COMPARE PRICE

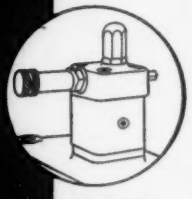
CHOICE OF CONTROLS



HANDWHEEL CONTROL, for quick, easy manual control of pump delivery.



STEM CONTROL for use with mechanical control of pump volume.



PRESSURE–COMPENSATING CONTROL, for fully automatic control of pressure and volume.

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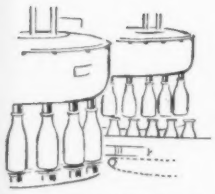
By the Makers of Vulcan Electric Soldering Tools.

VULCAN ELECTRIC COMPANY
DANVERS 18, MASS.

Makers of Electric Soldering Tools, Solder Pots and of a wide variety of Heating Elements for assembly into manufacturer's own products; and of Heating Specialties that use Electricity.

Stop Corrosion ...Use Globe Stainless Steel Tubes



When corrosion is found in tubing or metal parts formed from tubing, Globe Steel Tubes Co. can help you solve that problem. Not by suggesting just any stainless steel tubing . . . but by recommending the correct analysis and metallurgical properties of the Globe Stainless Steel Tubing to best meet your specific operating conditions.

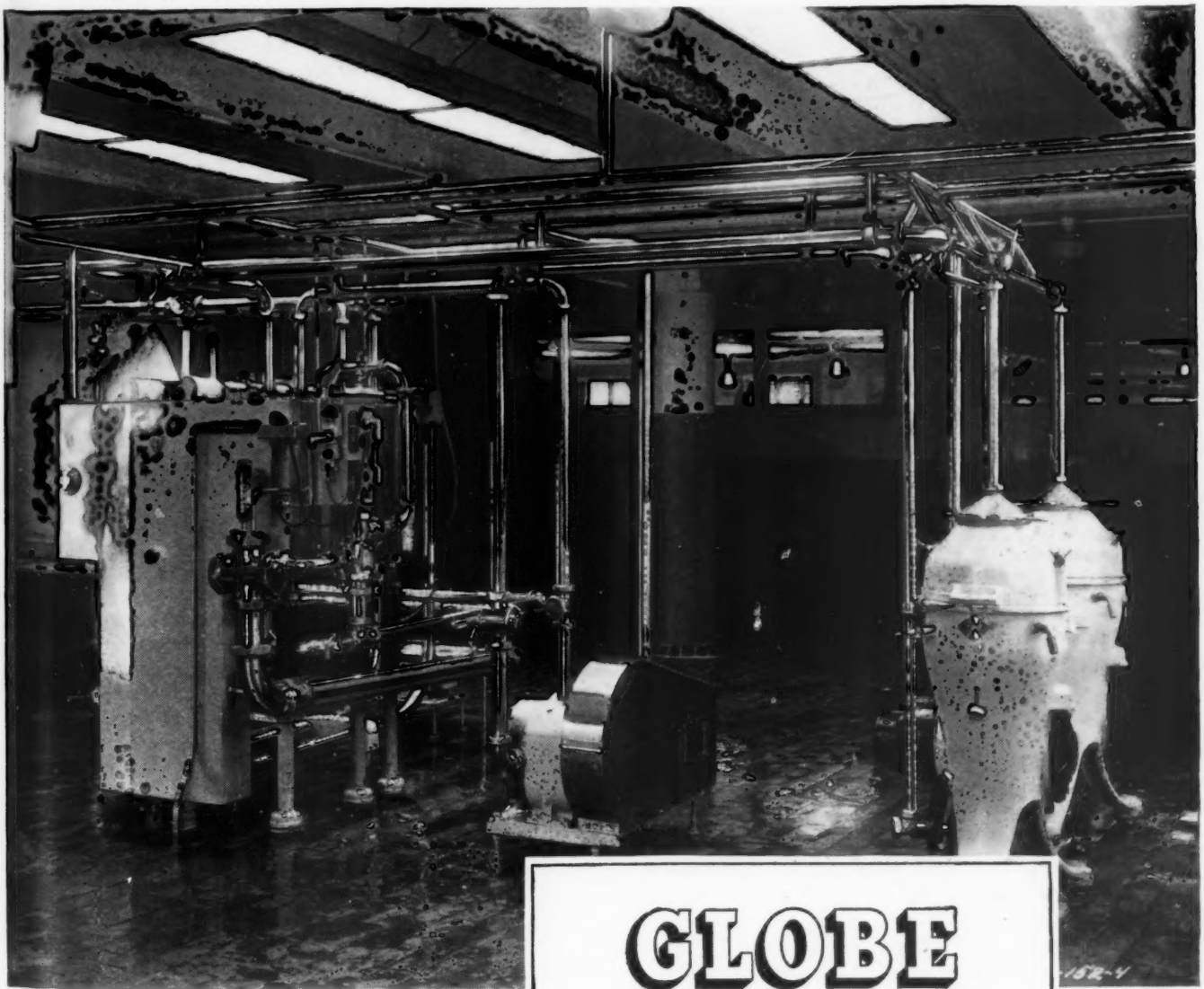
Globe Steel Tubes Co. can do this because they study the problem in cooperation with your engineers in your plant and in Globe's completely equipped metallurgical, physical and chemical laboratories. Result: You get recommendations for the specific analysis and metallurgical properties of stainless steel tubing in the size and finish you need to do your job best at maximum economy.

Globe Steel Tubes Co. has been rendering this service to industry for 40 years. Many of your problems involving tube failure, metallic contamination, corrosion, scaling and sanitation are an old story to Globe. Chances are, the answer to your problem is immediately available for the asking.

Let Globe Steel Tubes Co. assist you in surveying your tubing needs and problems, and you are assured of an outstandingly dependable source for steel tubing of all kinds: Stainless, Mechanical, Alloy Steel and Pressure . . . in a wide range of sizes and types to meet your requirements . . . plus the engineering and research facilities to solve your tubing problems.

GLOBE STEEL TUBES CO., Milwaukee 4, Wisconsin

Photo courtesy Creamery Package Mfg. Co.



GLOBE
Stainless
STEEL TUBES

Free valuable technical data in Globe Steel Tubes Co.'s new "Bursting Pressure Bulletin No. 112A".

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For Quick-Tightening Leakproof Hose Connections

Product and design engineers can look to WITTEK to help solve their hose connection problems. Wittek Hose Clamps, for over a quarter century known as standard equipment in the automotive and aviation industries, are today widely used on machines, engines and equipment requiring leakproof hose connections for air, oil, gas and water lines. Consult us on your hose clamping problems. Write for Literature.

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Hose Clamps for Every Application

WINNING POWER!

WISCONSIN HEAVY-DUTY *Air-Cooled* ENGINES

Four of a kind — winning power to spare in this hand! The same winning power you draw when you specify Wisconsin Air-Cooled Engines for your equipment . . . compact, heavy-duty singles in two types ranging from 2 to 9 hp.; twin-cylinder models from 7 to 13 hp., and V-type 4-cylinder engines from 15 to 30 hp.

All models are designed for heavy-duty service — delivering "Most Hp. Hours" of on-the-job service.

All models are extremely compact . . . to fit the machine as well as the job.

All models are built to one standard of top-quality excellence in design, materials and precision construction.

For "Winning Power", specify Wisconsin Air-Cooled Engines. Engineering data gladly supplied.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
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Make it better with GRAY IRON

Many a manufacturer has been led astray by the theory that because something is newer it must be better.

For example, certain products or components which are naturals for Gray Iron are made of other metals less advantageous for the purpose.

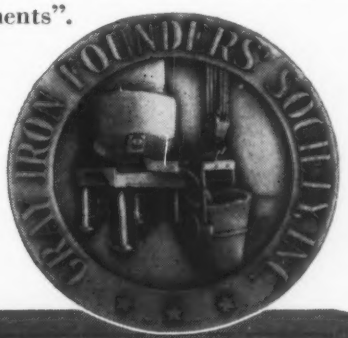
Maybe it's because gray iron castings have been around so long, some people have forgotten what an extraordinary array of advantages they offer. Then, too, many potential users—and even product designers—are not aware of the great improvements in gray irons in recent years.

Send for free booklet, "GRAY IRON—Its Mechanical and Engineering Characteristics and Details for Designing Cast Components".

In forthcoming messages in this series, each of the following advantages will be illustrated:

Castability	**Corrosion Resistance**
Rigidity	**Durability**
Low Notch Sensitivity	**Vibration Absorption**
Wear Resistance	**Machinability**
Heat Resistance	**Wide selection of mechanical properties**

GRAY IRON—second largest of the metal-working industries.



GRAY IRON FOUNDERS' SOCIETY, INC.

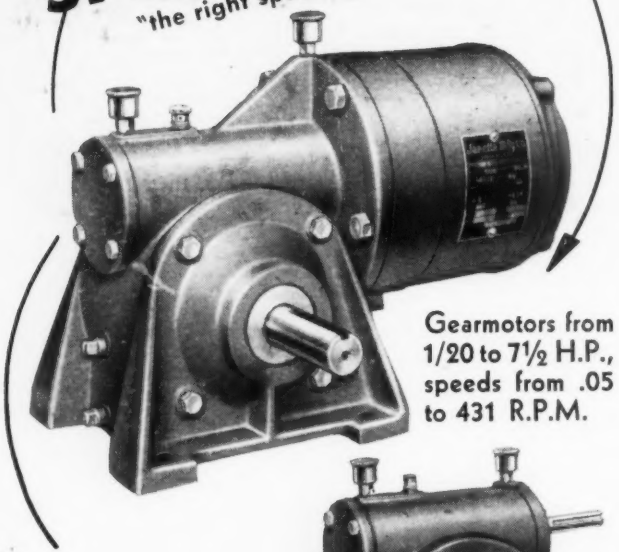
NATIONAL CITY BANK BLDG., CLEVELAND 14, OHIO

Janette

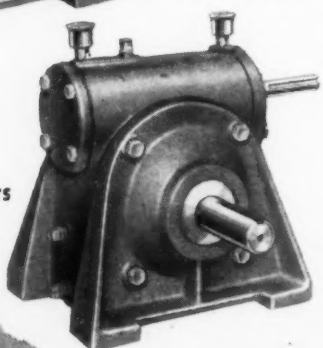
motorized and motorless

SPEED REDUCERS

"the right speed, the right power"



Gearmotors from 1/20 to 7½ H.P., speeds from .05 to 431 R.P.M.



Motorless speed reducers from 1/20 to 10 H.P.

22 types and 48 sizes, with wide variety of mechanical and electrical modifications and assembly positions to fit your individual need. Janette speed reducers feature worm and combination worm-and-planetary gearing for the most dependable performance under the widest range of operating conditions.

WRITE FOR OUR NEW BULLETIN 10-10

Janette MANUFACTURING COMPANY
556 W. Monroe Street
Chicago 6, Illinois

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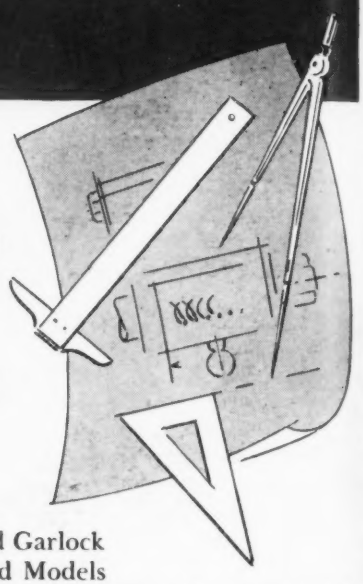


We'll Make it for You

In addition to standard Garlock KLOZURE Oil Seals and Models 53 and 63 KLOZURES, we design and manufacture special KLOZURE Oil Seals to meet every need. For instance, Model 54 Tangential Type KLOZURES for self-aligning or "spherical" roller bearings where the seal must do a job on a spherical surface; Double KLOZURES; Split KLOZURES; Special KLOZURES for Roll Necks, etc.

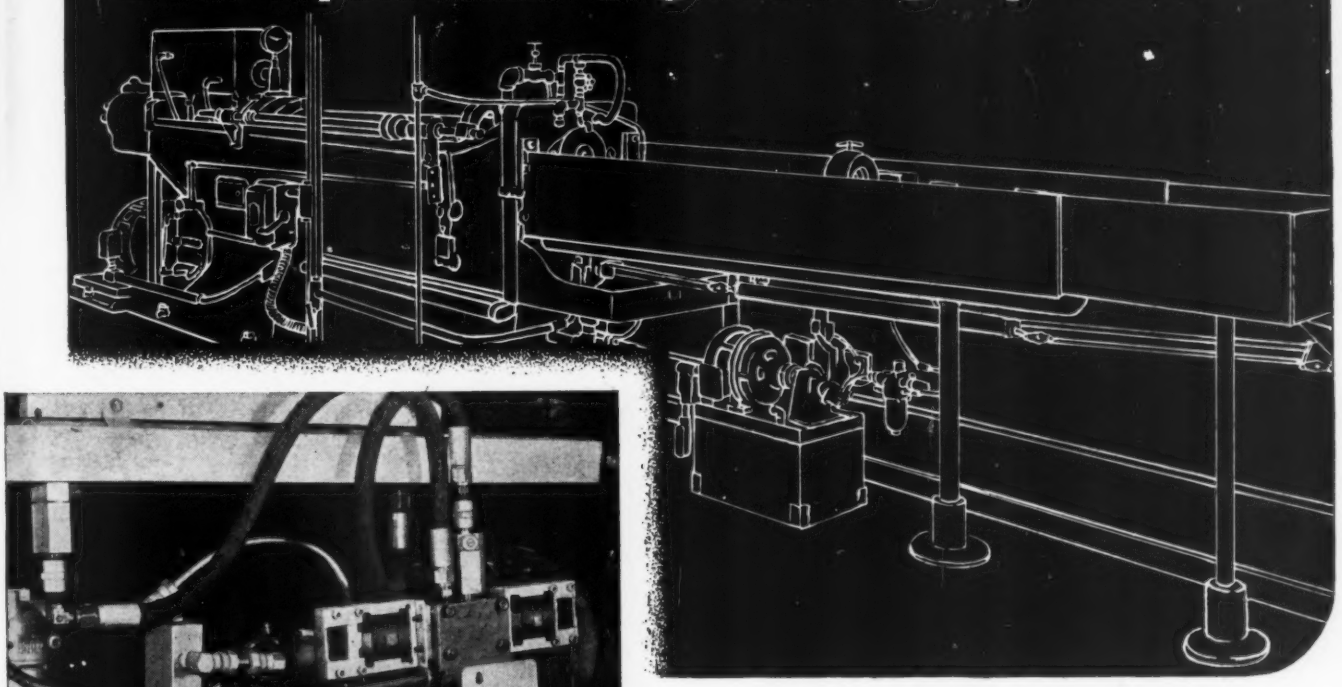
Garlock KLOZURE Oil Seals give superior service on all kinds of equipment—wherever there is a bearing. Tell us your oil seal problems and we will supply a KLOZURE to meet your special requirements.

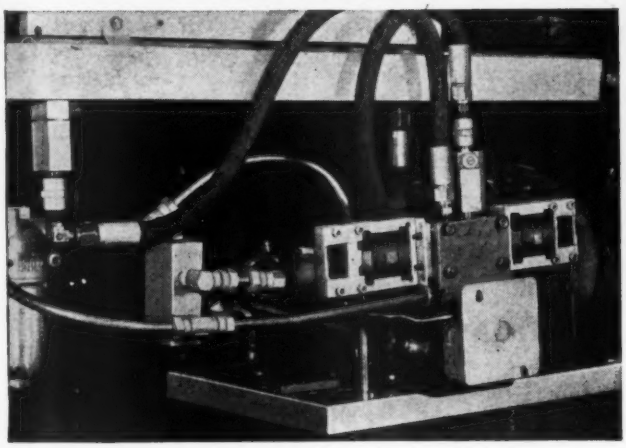
THE GARLOCK PACKING COMPANY
PALMYRA, N. Y.
In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK *Klozure** OIL SEAL

*Reg. U. S. Pat. Off.

Broaching Machines, too, MADE BETTER... with Hydraulic Engineering by Electrol





The Electrol hydraulic installation which provides push button control for broaching tools.

GONE are the days when it was necessary for an operator to advance and return a broaching tool *manually* to obtain clearance space for the working piece.

Today, with Hydraulic Engineering by Electrol, this back-breaking task—often requiring the time and labor of two men—is eliminated simply and inexpensively by operating and controlling the broaching tool *hydraulically*.

This way . . . it requires only the pressure of a finger-tip on an electric push button to engage or disengage the broaching tool—or to move the tail stock in either direction from a stationary point.

Perhaps, the machines you use—or the products you make—can be made better through the use of hydraulic devices. Electrol's engineering staff will gladly work with you.

• • •

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Save Metal •
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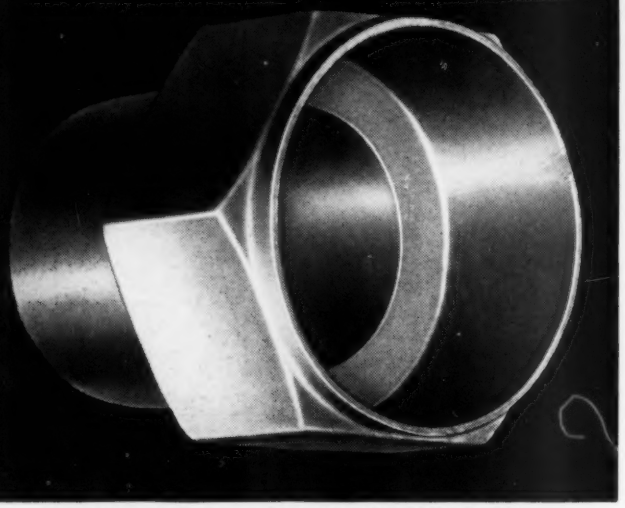

PHOTOGRAPHS COURTESY CO-OPERATIVE INDUSTRIES, INC.

Co-operative Industries, Inc. of Chester, N. J., estimate that they effect a saving of 16c each on the part shown above, used in Duraflex Metal Hose assemblies. This silicon bronze part is cast by Ohio Precision in plaster molds. As a result, smoothest surfaces and closest tolerance are obtained. Machine work is reduced to an absolute minimum, saving time and metal. Ohio Precision can save *you* time and money: **1.** When machine production wastes metal. **2.** When sand castings won't meet specifications. **3.** When quantities are too small to warrant expensive dies. **4.** When you're waiting for dies and in a hurry for parts. Ohio Precision plaster mold castings will solve *your* production problems!

OHIO PRECISION FEATURES

CLOSEST WORKING TOLERANCE
plus or minus .005 of an inch

NO MIS-MATCH TOLERANCE
Ohio Precision makes them match

SMOOTH FINISH
minimizes costly machine work

MANY AVAILABLE SIZES
up to 8" wide, 10" long, 8" high

ADAPTABLE AND REASONABLE
saves expense of costly dies for experimental work

FOR COMPLETE COST FACTS, SEND PRINTS AND SPECIFICATIONS TODAY!

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Plaster Mold Castings Made From Brass • Bronze • Aluminum • Beryllium Copper

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—everything YOU want in

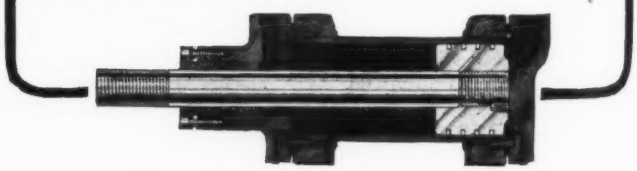
HYDRAULIC CYLINDERS

● **SUPERIOR DESIGN.** An improved type of high pressure hydraulic cylinders. Universal end caps for easy insallation and simplified piping . . . tight sealing precision type honed piston rings for maximum power, lasting "leakproof" operation. No-tie-rod design.

● **PRECISION CONSTRUCTION.** Cylinders *"TRU-BORED"* from steel and honed to satin finish by exclusive Hannifin long stroke honing process. Close tolerances between piston and cylinder. Manufactured with precision tooling throughout to insure complete interchangeability of parts.

● **COMPLETE LINE.** 12 standard bore diameters, 1" to 8"... any length stroke you specify... 11 standard mounting styles... standard, double end, or heavy duty (2:1) piston rods... available with adjustable cushions... pressures to 1500 lbs. per sq. in. Special types built to order.

● **ENGINEERING RECOMMENDATIONS.** Let Hannifin engineers help you get the BEST solution for your hydraulic cylinder problems. See your local Hannifin representative, or write.



This sectional view shows the patented construction of Hannifin double acting Hydraulic Cylinders. Note the simple, compact, and rugged construction . . . long bearing surfaces . . . full 4-ring piston construction.

HANNIFIN CORPORATION

1101 S. Kilbourn Ave., Chicago 24, Illinois

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PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES

Any V-BELT Changes Shape *when it Bends*

Prove this yourself!

That's Why the CONCAVE SIDE

(U. S. PATENT NO. 1813698)

Gives You 2 Big SAVINGS!

Bend *any* V-Belt and *f e e l* it change shape. The top, under tension, *narrows*. The body, under compression, *widens*. The sides of the belt bulge out.

Straight-Sided V-Belt

Straight-Sided V-Belt Bulges in Sheave-Groove.

The result, if the belt is built with *straight* sides, is a shape that does not fit the sheave groove — as shown in Figures 1 and 1-A, above.

Now, bend the V-Belt built with the precisely engineered Concave Side (U. S. Patent No. 1813698) — the Gates Vulco Rope.

Gates Vulco Rope With Concave Side.

No Side Bulge. Precise Fit in Sheave Groove.

You get the same shape change but *now* the new shape *exactly fits* the sheave groove as shown in Figures 2 and 2-A.

Results— (1) *Uniform* side-wall wear; *longer* life. (2) *Full* side-wall grip on the pulley; carries heavier loads and sudden load increases without slippage—a big increase in drive efficiency—saving belt wear a n d also saving power!

REG. U. S. PAT. OFF.

The Mark of SPECIALIZED Research

The Concave Side is MORE IMPORTANT NOW Than Ever Before

Because the *sides* of a V-Belt are what actually *drive* the pulley, it is clear that any increased load on the belt means a heavier load that must be transmitted to the pulley *directly* through the belt's side-walls.

Now that Gates *SPECIALIZED* Research has m a d e available to you SUPER Vulco Ropes—carrying fully 40% higher horsepower ratings—the life-prolonging Concave Side naturally delivers greater savings today than ever before.

4812

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Engineering Offices and Jobber Stocks IN ALL INDUSTRIAL CENTERS of the U. S. and 71 Foreign Countries

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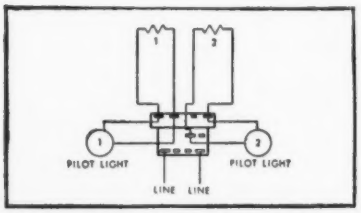
"The World's Largest Makers of V-Belts"

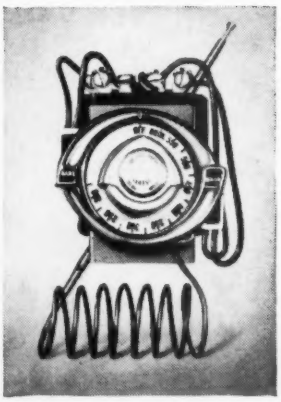
The Robertshaw Model C-1 shown here is a combination thermostat and selector switch. It automatically switches from "Preheat" to "Bake".

For fast preheating of oven, dial is turned to "Broil" position first, then to the temperature setting desired. This turns ON both the lower baking and upper broiling elements. Both the "Bake" and "Broil" pilots turn ON. When oven reaches set temperature both pilots turn OFF, signalling that oven is at pre-heat temperature and ready for food to be baked or roasted. The broiling element will automatically remain out of the circuit and the set oven temperature will be maintained by cycling of lower element only. For low temperature and slow pre-heat, dial is turned from OFF to desired temperature, thus throwing on the lower element only.

Write for full information about this and other Robertshaw Thermostats for home appliances.



Wiring Diagram No. R-2385-C—SLOW HEAT. *A Element* #1—Turn dial to any temperature. Element #1 cycles at set temperature. *B Element* #2—Turn dial to maximum temperature. Element #2 cycles at maximum temperature. FAST HEAT. Turn dial to maximum temperature then back to desired temperature. When set temperature is reached, elements #1 and #2 are automatically disconnected and after that only element #1 is cycling at set temperature.



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Robertshaw-Fulton
CONTROLS COMPANY
ROBERTSHAW THERMOSTAT DIVISION
YOUNGWOOD, PENNSYLVANIA

Purebon

solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

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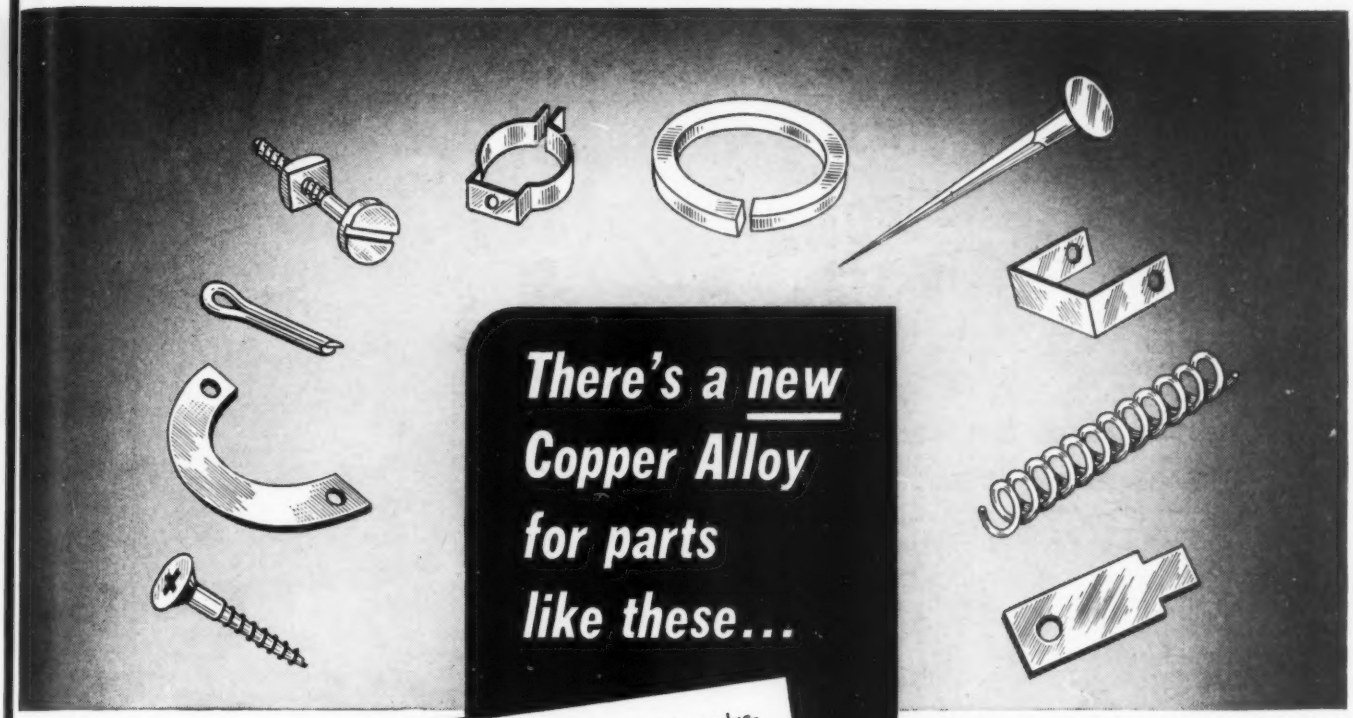

Typical parts made from round or flat wire

It combines tensile strength and conductivity to a unique degree . . . is unusually malleable . . . is resistant to stress corrosion and offers excellent resistance to creep at elevated temperatures.

CHASE patented PHOSNIC® BRONZE

HERE'S a radically different type of copper alloy that you'll want to investigate—PHOSNIC BRONZE, made *only* by Chase.

PHOSNIC BRONZE is exceptionally malleable, permitting severe cold heading even after hard drawing to attain high strength. In this condition its resistance to stress corrosion is outstanding. Special spring temper wire attains a tensile strength of 120,000 psi—yet even then has an electrical conductivity of 50% IACS with correspondingly high thermal conductivity. This combination of strength and conductivity, characteristic of Phosnic Bronze, is unmatched by any other commercial alloy.

PHOSNIC BRONZE is of particular interest where phosphor bronze, silicon bronze and cartridge brass have been used in the past. Phillips head screws, nuts, switch parts, fuse clips, lock washers, cotter pins, springs — these are just a few of the potential applications.

PHOSNIC BRONZE is supplied in the form of rod, round wire, rolled flat wire and tube—in tempers ranging from age-hardened condition up to and including special spring.

Mail the coupon for the full story of this remarkable new copper alloy.

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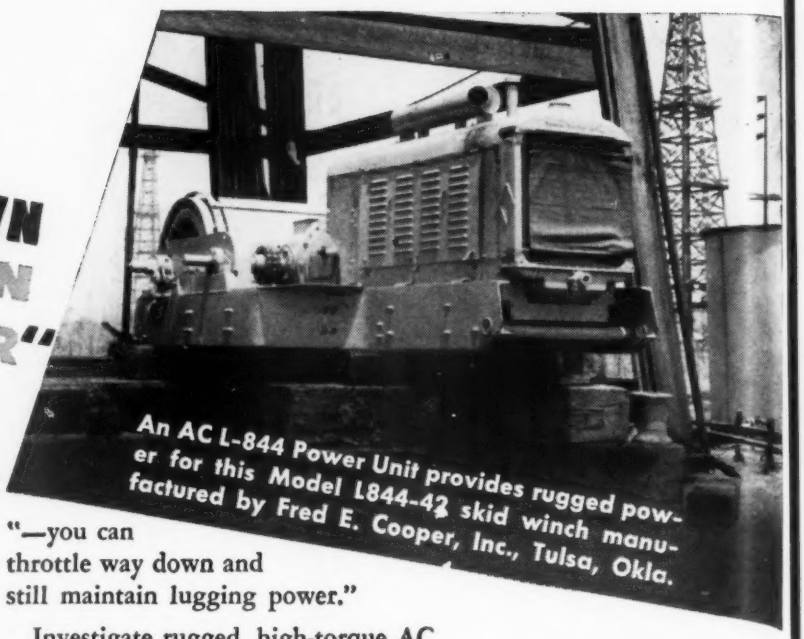
AC Engines

"THROTTLE WAY DOWN and STILL MAINTAIN LUGGING POWER"



An AC L-844 Power Unit provides rugged power for this Model L844-42 skid winch manufactured by Fred E. Cooper, Inc., Tulsa, Okla.

. . . says Winch Manufacturer

Winches for servicing oil wells require rugged power—require engines that can pull thousands of pounds of pipe, hang onto heavy overloads like steam power.

That's why Cooper winches are equipped *exclusively* with heavy-duty Allis-Chalmers Power Units. They provide high torque at slow speeds. "This gives the necessary lug for heavy loads," states the Fred E. Cooper company, "—you can throttle way down and still maintain lugging power."

Investigate rugged, high-torque AC Engines for your own products. Production-line built, their first cost is low — so are operating cost and upkeep. Accessories to fit the application. Choice of fuels. Nation-wide service facilities. Let our power engineers help select the unit for your requirements.

A SIZE TO FIT YOUR NEEDS

MODEL*	R.P.M.	MAXIMUM BRAKE HP.
B-125	1500—1800	24.5—28.0
W-201	1400—1800	33.5—40.5
U-318	1200—1400	45.0—50.9
E-563	1050	74.0
L-844	1050	110.0

*figures represent cu. in. displacement

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Sier-Bath GROUND or SHAVED Gears

. . . for a More Compact Assembly

● The more accurate the gear, the smaller the required size for a given load or a given speed. This makes possible more compact assemblies. Sier-Bath is fully equipped with the latest, most efficient machinery for shaving spiral and spur gears up to 24" diameter and for grinding spur gears to 16", spiral gears to 10", splined shafts (both straight side and involute) up to 42" long. Send us your specifications for quotation.

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The new No. 418 Miniature Ball Bearing: ¼"o.d. ⊙ ⅛"bore. Available in both chrome steel and stainless.

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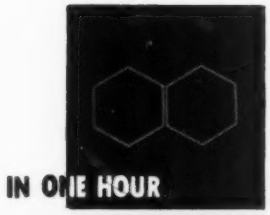
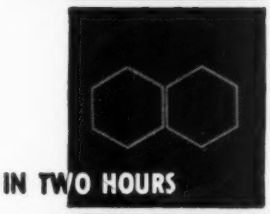
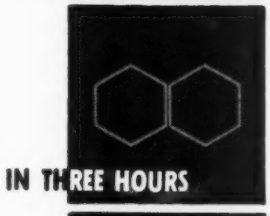
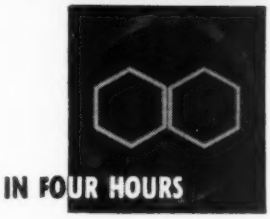
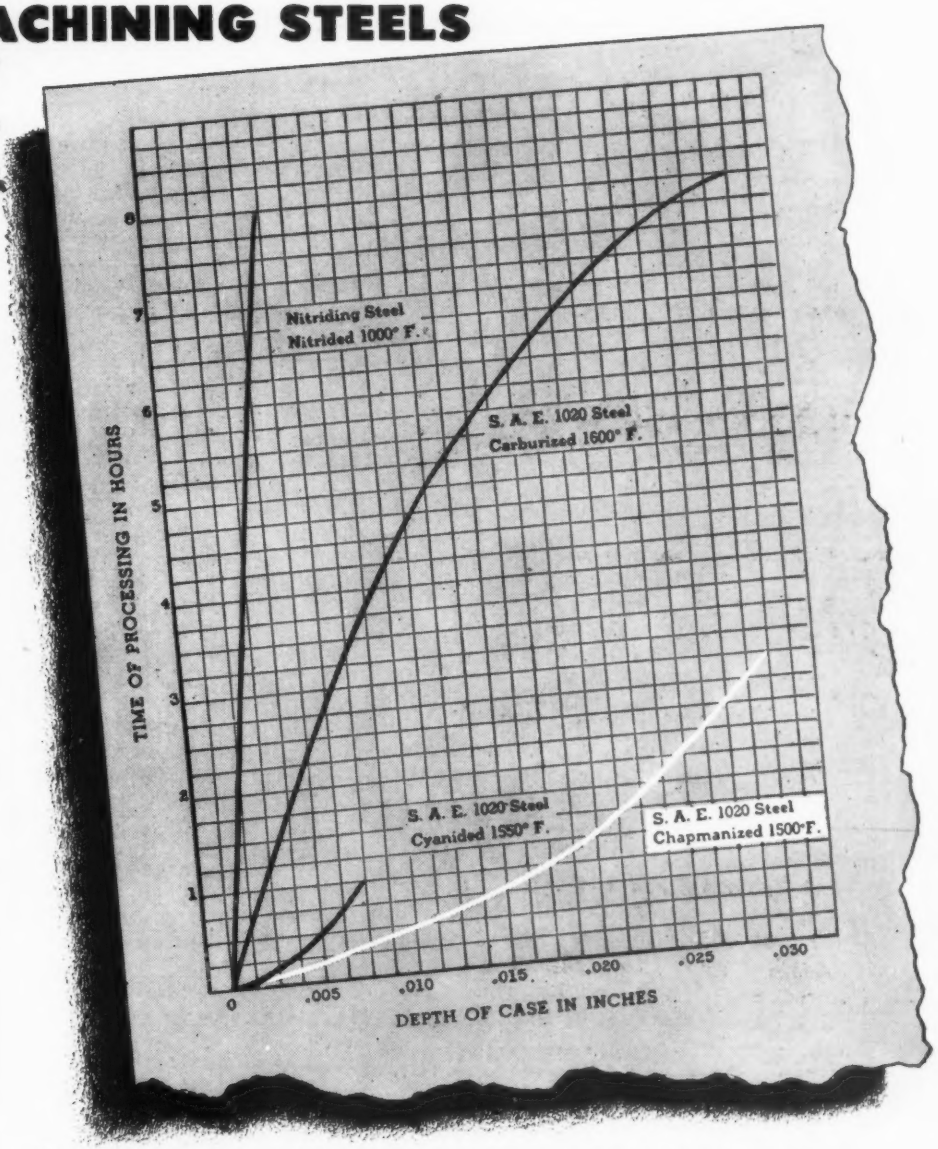










Here's the *efficient, modern way* to give free-machining steels an alloy-like case. It's fast. It's inexpensive. It gives you the controlled depth of case you need (between .002" and .035") in one to four hours. So tough and ductile is this case that there is no checking or chipping. Parts won't warp. The surface is silver-clean . . . ready for use with minimum finish-grinding.

Try Chapmanizing today. Send your parts to us, or write for the name of the nearest licensed Heat Treater. Or, let us hook a unit to your own pot-type furnace. Then you can Chapmanize right in your own plant on a contract basis.

Metallurgical Sales Division of

THE CHAPMAN VALVE MFG. CO.

INDIAN ORCHARD, MASSACHUSETTS

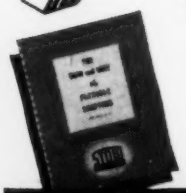
WITH STOW Flexible SHAFTING

Here's another instance where STOW Flexible Shafting simplifies design and steps up production

● A millwork drilling operation at the H. T. Hunt Company of Binghamton, N. Y. was shortened from 2 days to 1½ hours by means of the boring fixtures shown above. Any number of holes up to five can be drilled at the same time. Shafts and drills can be readily rearranged for variously spaced holes on other jobs.

STOW Flexible Shafting made this simple, efficient design possible because it transmits driving power to off-center or out-of-line locations—from almost any angle of approach. Holes can be drilled closer together than by any other means. And other similarly simple fixtures employing STOW Shafts can be made for drilling holes in *any* plane. So, when you want to simplify *your* power transmission designs, and obtain wide flexibility of applications, remember the advantages of STOW Flexible Shafting — the logical solution to many design problems.

★ **For more information, send today for your copy of "The How and Why of Flexible Shafting." It's FREE.**



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ONAN *Two-Cylinder* ENGINES

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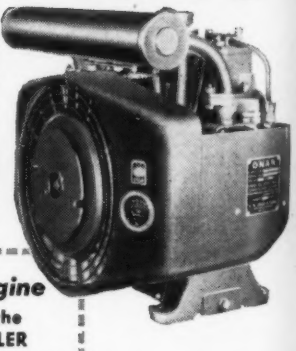

The Onan 10 HP CK Engine

powers the M. E. TILLER

Smooth-running, powerful and rugged, the CK engine gives this new tiller outstanding performance.

ONAN AIR-COOLED ENGINES: CK—2-cyl., 10 HP; BH—2-cyl., 5½ HP. IB—1-cyl., 3¼ HP.

SMOOTH POWER, inherent in the two-cylinder, horizontally-opposed, alternate-firing design of the Onan CK engine will give *your* mechanized equipment performance that *sells!* Lightweight, (only 97 lbs.) compact design simplifies installation. Built for heavy-duty use.

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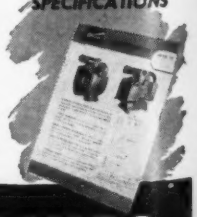

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5088 Royalston Ave., Minneapolis 5, Minn.

Onan PRODUCTS

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Use any standard fabricating method you wish!

The bond is inseparable.

SuVeneer Clad Metal's solid copper, monel or nickel cladding is bonded to low-carbon strip steel *for keeps!* It cannot be separated by mechanical means—you can use full freedom in new product design and count on dependable fabrication results. Get the special benefits of these solid metals combined with a strip steel base—specify and use *SuVeneer Clad Metal!*

Copper Clad

Monel Clad

Nickel Clad

SuVeneer®

CLAD METAL

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

SIMPLIFY *and Save*

Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- LOW COST
- PRECISION
- QUIET
- LONG LIFE
- CORROSION RESISTANT
- UNIT CONSTRUCTION
- LOAD CARRYING CAPACITY
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE

Are you buying more bearing than you need? Are you building sales resistance into your product by making it too complicated? One of the easiest ways to simplify the design and operation of a motive unit . . . without sacrificing performance or efficiency . . . is to install Johnson Sleeve Bearings.

The adoption of Sleeve Bearings brings many worthwhile advantages. It gives the designer more freedom in tolerances. It simplifies installation, also maintenance and replacement. The solid bearing surface provides excellent load carrying capacity. This bearing surface permits a continuous film of lubricant to form between the bearing and shaft . . . preventing wear, eliminating noise and reducing friction to the minimum.

Johnson Sleeve Bearings are more economical too. Their low unit cost provides manufacturers with a much lower cost and a greater profit on each model. They are precision made . . . of highest quality materials. Why not investigate the possibilities of using Johnson Sleeve Bearings in your product? We can give you sound advice and excellent delivery—NOW.

JOHNSON BRONZE CO.
508 S. Mill Street, New Castle, Pa.

Branch Offices

Atlanta
Buffalo
Cambridge, Mass.
Chicago
Cincinnati
Cleveland
Dallas
Detroit
Kansas City, Mo.
Los Angeles
Minneapolis
Newark
New York
Philadelphia
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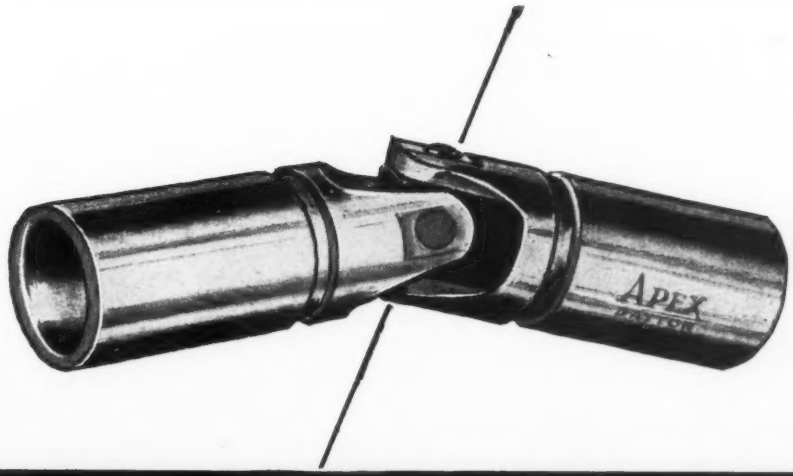
St. Louis
Seattle



*THIS seals lubricants IN and keeps trouble OUT

Only APEX Universal Joints come *Lubricated for Life!* The hermetically sealed cover, an exclusive Apex feature, enables you to design these joints into food machinery, packaging, paper and textile machinery—or *wherever* the finished products must be protected against oil.

These covers extend service life way beyond all previous limits and permit the use of joints in corrosive or abrasive laden atmospheres or liquids at extremes of temperature.

Apex Heavy Duty Universal Joints are made in sizes from ⅜" to 4" diameters. In addition to high strength weight ratio their unique structural design assures low deflection rate, low wear, superior fatigue resistance and overload capacity and long life.

For complete information, write for Catalog No. 103A.

The Apex Machine & Tool Co., 1033 S. Patterson Blvd., Dayton 2, Ohio

APEX

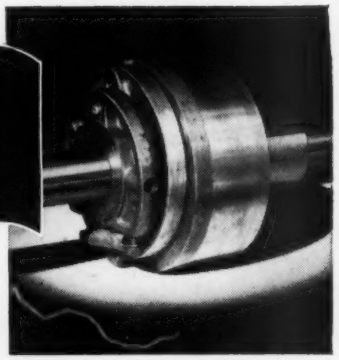
universal joints

Safety Friction Tapping Chucks • Quick Change and Positive Drive Drill Chucks • Vertical Float Tapping Chucks • Parallel Floating Tool Holders • Power Bits for Phillips, Slotted Head, Frearson and Clutch Head Screws • Hand Drivers for Phillips and Clutch Head Screws • Aircraft and Industrial Universal Joints • Sockets and Universal Joint Socket Wrenches

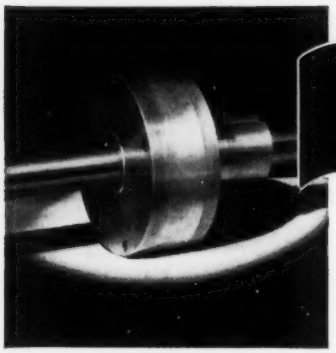
HILLIARD *Clutches*

FOR POWER CONTROL DESIGNS

HILLIARD SINGLE REVOLUTION CLUTCH



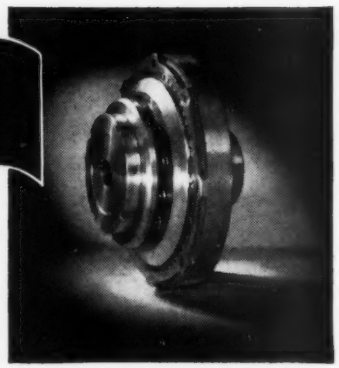
Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



HILLIARD OVER-RUNNING CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

HILLIARD SLIP CLUTCH



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations; and many other uses.

Hilliard's Engineering Department is ready to assist you in designing installations and in selecting the correct clutch or coupling.
Write today — 3 Hilliard Clutch Bulletins with design information. Free on request.

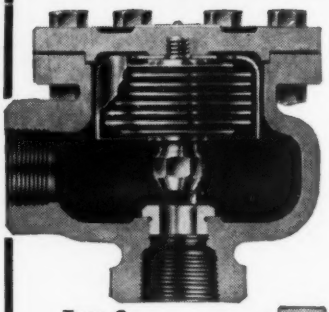
Clutch Makers for over 40 years

The HILLIARD Corporation
101 W. Fourth St., Elmira, N. Y.

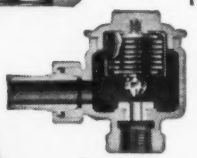
We Invite You

TO TEST NICHOLSON STEAM TRAPS FOR

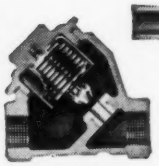
LOWEST STEAM LOSS
LARGEST CAPACITY



Type C



Type AU



Type AHV

See why an increasing number of America's leading plants are standardizing on Nicholson traps.

Comparative tests by large trap users show: record low for steam waste; 2 to 6 times average drainage capacity; operate on lowest temperature differential; no freeze-ups; greater simplicity (fewer spare parts). 5 types for every -purpose; size ¼" to 2"; pressures to 225 lbs. Test trap gladly sent. BULLETIN 1047.

W. H. NICHOLSON & CO. 200 OREGON STREET WILKES-BARRE, PA.

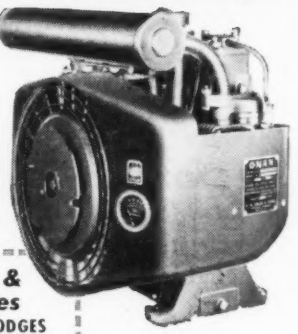
Valves • Traps • Steam Specialties

Solve prime mover problems with—

Smooth Power

ONAN
Two-Cylinder
ENGINES

10 & 5½ HP • AIR-COOLED



Onan CK & BH Engines
power the HODGES DISC SHARPENER
Smooth-running, powerful and rugged, CK and BH engines give this power tool outstanding performance.

ONAN AIR-COOLED ENGINES: CK—2-cyl., 10 HP; BH—2-cyl., 5½ HP. 18—1-cyl., 3¼ HP.

SMOOTH POWER, inherent in the two-cylinder, horizontally-opposed, alternate-firing design of the Onan CK and BH engines will give *your* mechanized equipment performance that *sells!* Lightweight, compact design simplifies installation. Built for heavy-duty use.

WRITE FOR SPECIFICATIONS

Onan PRODUCTS

D. W. ONAN & SONS INC.
5088 Royalston Ave., Minneapolis 5, Minn.

ONAN 4-Cycle ENGINES

No other socket screw can be wrenched up as tightly as

BRISTOL'S MULTIPLE-SPLINE!

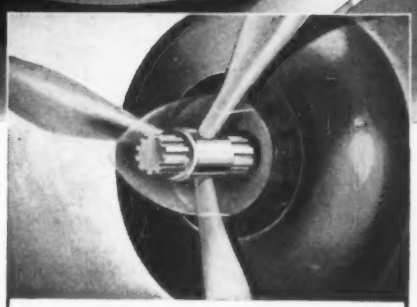
Because of Bristol's Multiple-Spline design, all the force applied in wrenching up is directed into *rotary motion*. This permits tightening far beyond the limits of ordinary screws. Result: tighter grip . . . greater holding power!

CONQUER VIBRATION . . . Bristol's Multiple-Spline socket screws resist loosening under severe shock and vibration . . . are ideal for vibrating shafts . . . for mechanisms frequently disassembled . . . for hard-to-reach fastening points.

PRECISION THREADING . . . careful design, close tolerances plus a complete inspection system add up to a product that is accurate, uniform, spins easily into place, fits perfectly, wrenches up tightly . . . gives you quicker, easier fastening . . . lowered assembly costs.

INTERNAL WRENCHING . . . gives design advantages — less pocket allowance in your product for wrench movement . . . reductions in flange sizes — makes possible neater, more compact design.

Write for bulletin and prices. THE BRISTOL COMPANY, Mill Supply Division, 121 Bristol Road, Waterbury 91, Connecticut.

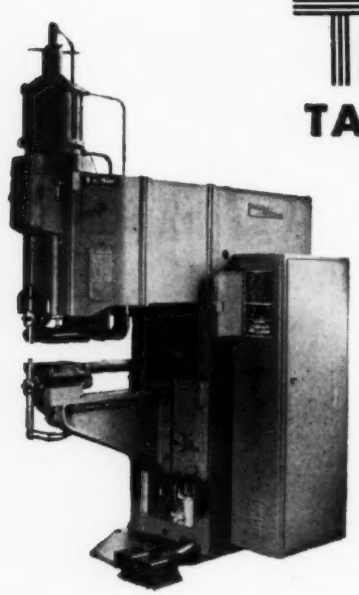


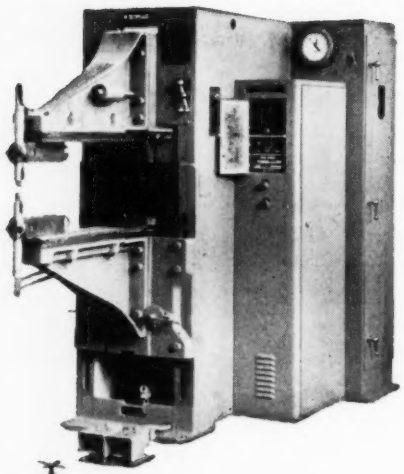
MOST EFFICIENT MECHANISM FOR TRANSMITTING TORQUE

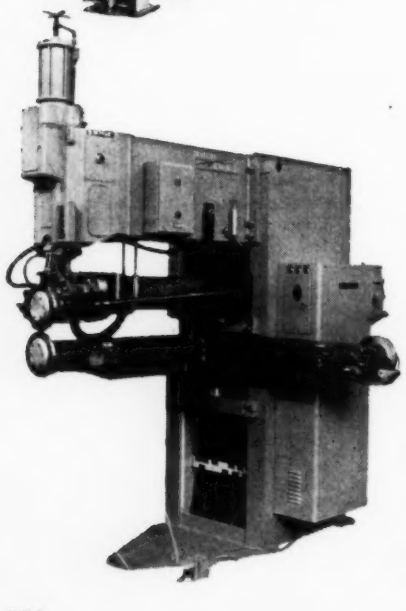
The multiple-spline principle is used on aircraft propeller shafts and on automobile transmission shafts because of its high efficiency in transmitting torque. In socket screws, the multiple-spline directs all the wrenching force into *rotary motion* . . develops greatest holding power.

The BRISTOL Company
MILL SUPPLY DIVISION

95% POWER FACTOR
BALANCED THREE PHASE
WITH
Tri-Phase
TAYLOR-WINFIELD WELDERS
(RESISTANCE)







Six Highly Desirable Features . . . (1) greatly reduced power demand; (2) three phase balanced power load; (3) desirable high power factor (95%); (4) improved weldability; (5) deeper throat depths with essentially no increase in power demand; (6) with Tri-Phase, you can weld low carbon steel, stainless steel, aluminum alloys, magnesium, Monel, Inconel, brass alloys, and other materials on same welder.

Tri-Phase can be had in spot, projection, seam, or upset-butt welders. Ask for Tri-Phase Bulletin 10-813 just off the press.

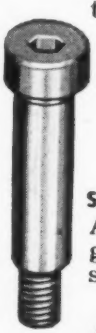
THE TAYLOR-WINFIELD CORPORATION
WARREN, OHIO, U.S.A.

TAYLOR-WINFIELD
RESISTANCE WELDERS

The COMPLETE line...

Blue Devil
SOCKET SCREW PRODUCTS

Socket Cap Screws
Sturdy, cold-formed head—continuous fibre structure.



Socket Stripper Bolts
Accurately ground shoulder.

Socket Set Screws
Precision-ground thread with rust-resistant finish—five point styles

Socket Pipe Plugs
Safer, stronger—excellent seal. Made of alloy steel.

Flat Head Cap Screws
Flush type screws. Fit standard countersink.

Socket Screw Keys
Minimum play between key and socket.

Blue Devil
SOCKET SCREW PRODUCTS

SAFETY SOCKET SCREW CO.
4448 N. KNOX AVENUE CHICAGO 30, ILL.
11 Park Place New York 7, N. Y.

"Built-In" Lubrication for Sales-Minded Machine Design

A
"BOUND BROOK"
PRODUCT

COMPO® Oil-Retaining Porous Bronze Bearings

Longer life and trouble-proof service.

• • •

Lubrication for thousands of operating hours, without oil renewal.

• • •

Great Accuracy—Die-formed to close tolerances.

• • •

No oil holes or grooves.

• • •

Lowers installation, operating and maintenance costs.

Design improvement is the engineer's way to increased sales: another way of saying progressive engineers are sales-minded.

"Built-In" Lubrication, for the life of most machines and appliances, is an irresistible sales feature, especially where lubrication failure on inaccessible assemblies is indicated.

Specify "Compo" oil-retaining porous bronze bearings, for "Better Machines and Appliances."

Eliminate oil spatter and contamination of the processed goods.

• • •

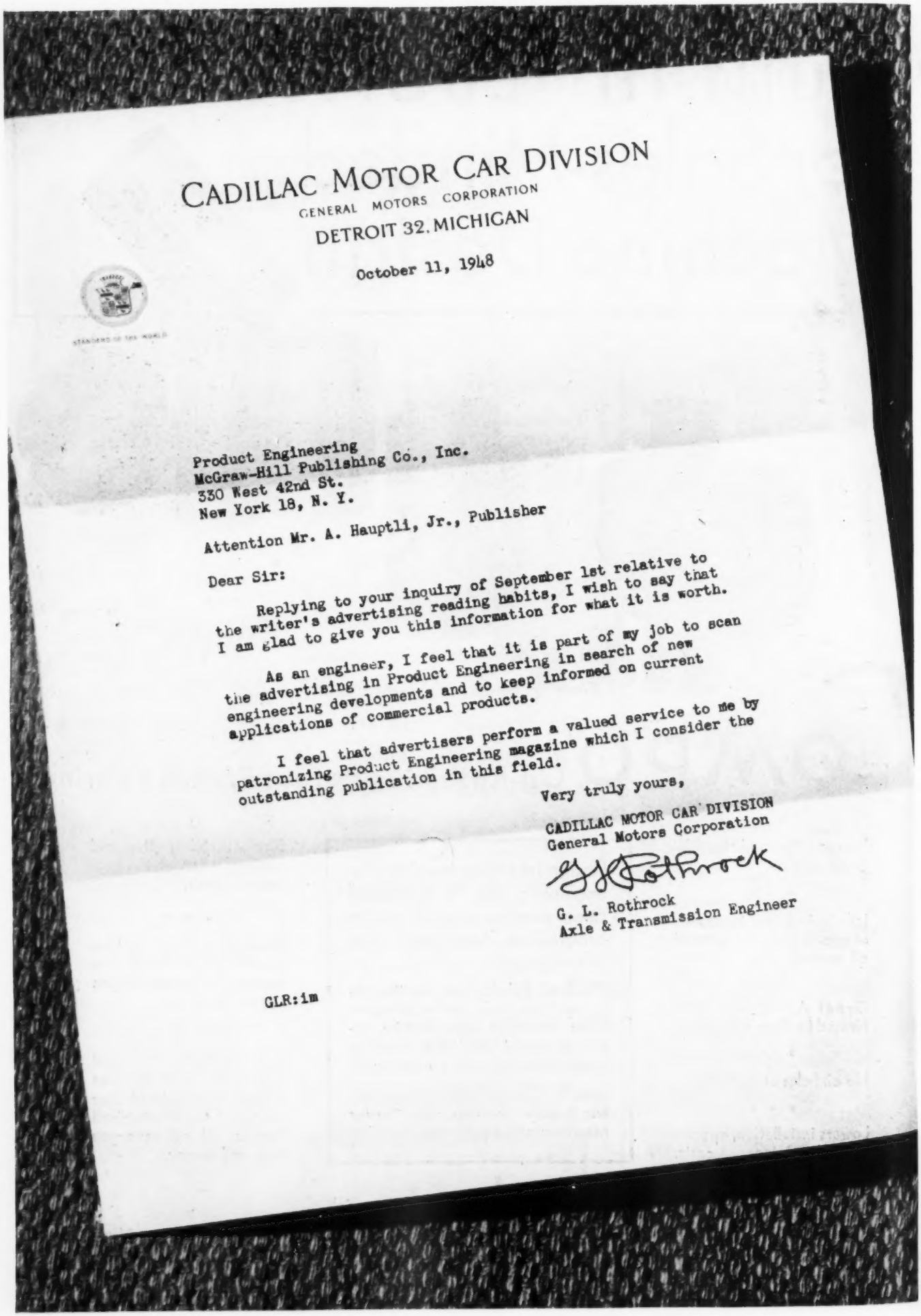
Immediate Shipments—send for Stock List of many sizes in all standard shapes carried in stock.

• • •

Save production time and tool costs—write for Size List of Thousands of Dies on Hand for all standard Shapes. It will save you time and money.

BOUND BROOK OIL-LESS BEARING COMPANY • Established 1883 • Manufacturers of Metal Powder Products Since 1921

Main Office and Plants: Bound Brook, New Jersey • Branch 1255 Book Building, Detroit 26, Michigan
Sales and Service Representatives: Ritchie Engineering Company, 3509 Irving Avenue, South, Minneapolis 8, Minnesota
Atlas Brass Foundry, Inc., 1901 Santa Fe Avenue, Los Angeles 21, California • In Canada: Dominion Bearings, Ltd., 272 Van Horne Street, Toronto



CADILLAC MOTOR CAR DIVISION
GENERAL MOTORS CORPORATION
DETROIT 32, MICHIGAN

October 11, 1948

Product Engineering
McGraw-Hill Publishing Co., Inc.
330 West 42nd St.
New York 18, N. Y.

Attention Mr. A. Hauptli, Jr., Publisher

Dear Sir:

Replying to your inquiry of September 1st relative to the writer's advertising reading habits, I wish to say that I am glad to give you this information for what it is worth.

As an engineer, I feel that it is part of my job to scan the advertising in Product Engineering in search of new engineering developments and to keep informed on current applications of commercial products.

I feel that advertisers perform a valued service to me by patronizing Product Engineering magazine which I consider the outstanding publication in this field.

Very truly yours,

CADILLAC MOTOR CAR DIVISION
General Motors Corporation

G. L. Rothrock

G. L. Rothrock
Axle & Transmission Engineer

GLR:im

Economics of ALLEGHENY METAL

Research Results: Especially in acid or salt atmospheres (industrial or coastal areas) Stainless Steel Guy Wire is far better and cheaper than any other type. First cost, installed, is 20% above Material B and 40% above Material C (two commonly-used coated wires) but Allegheny Metal Guy Wire outlasts either of these materials many times over. The very first time that "B" or "C" must be replaced—and this may be necessary as often as every three to five years—Allegheny Metal saves 40% in costs over "B" and 30% over "C" . . . Plus 40% less weight to handle, transport and store . . . Plus greater reliability, maximum protection against chafing and impact, and decades of re-use.

Memo: **To anyone who uses GUY WIRE on poles, stacks, towers, signs, buildings, etc., ALLEGHENY METAL is best and cheapest in the long run . . . why not investigate it?**

Complete technical and fabricating data—engineering help, too—yours for the asking.

ALLEGHENY LUDLUM STEEL CORPORATION

The Nation's Leading Producer of Stainless Steel in All Forms

Pittsburgh, Penna. . . . Offices in Principal Cities

Allegheny Metal is stocked by all Jos. T. Ryerson & Son, Inc., Warehouses

In hydraulic pumps

GEROTOR

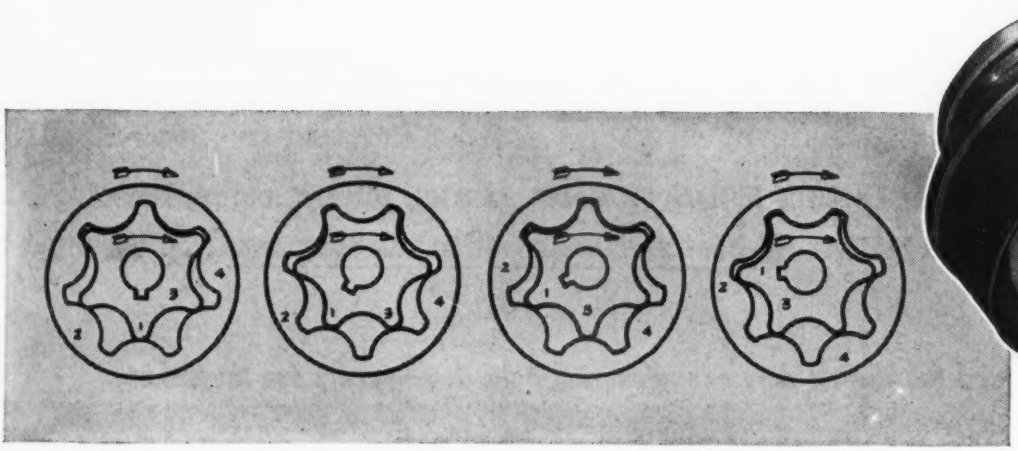
is more than a name—

it's the principle of the thing!

The unique Gerotor principle, found in no other hydraulic pumps, operates with high volumetric and mechanical efficiency. Both Gerotor elements revolve in the same direction at low relative speed, resulting in less wear, longer life. Continuous fluid-tight tooth engagement means less slippage, more uniform flow. Note the relative advance of teeth and spaces in the diagrams below.

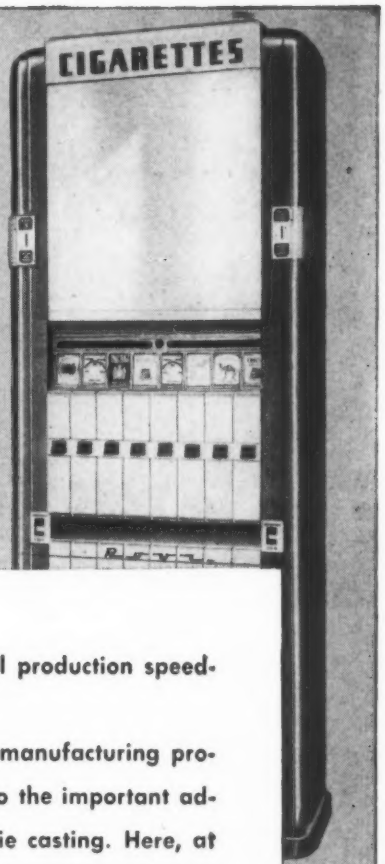
Gerotor hydraulic pumps are engineered for pressures up to 1000 p.s.i., continuous duty; in some sizes, up to 1200 p.s.i., continuous, and 1500 p.s.i., intermittent. Deliveries range from .4 g.p.m. at 1800 r.p.m. to 40 g.p.m. at 1200 r.p.m. Plain, base or flange mounting. Models available for two separate circuits. Write for Catalog Sections G-101, G-103, G-104, G-106.

GEROTOR MAY CORPORATION—P. O. Box 86, Baltimore 3, Maryland



GEROTOR hydraulic pumps, motors, valves and cylinders • air valves and cylinders

DIE CASTING steers your money to the best "buy"



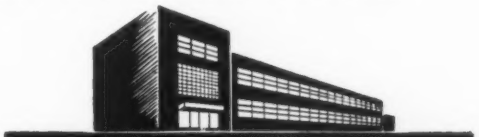
CASE HISTORIES FROM MT. VERNON FILES

Whether your product be large or small, simple or complex, you'll find die casting can lead to new production economies and product improvements.

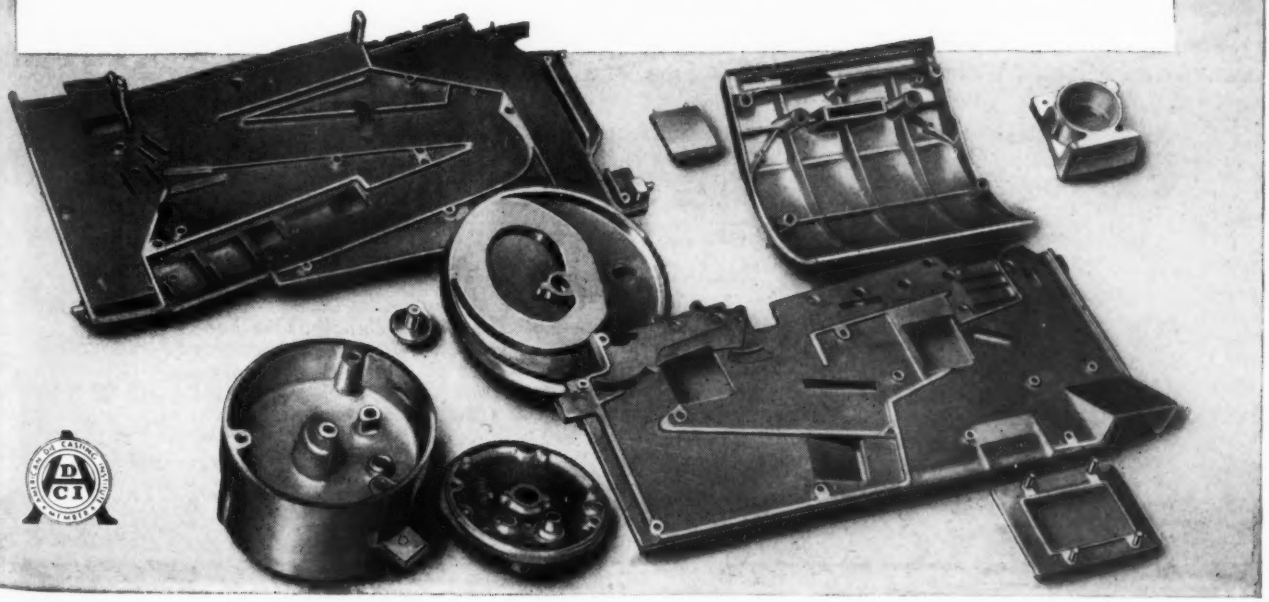
Consider these components of a vending machine. Die cast by Mount Vernon for Rowe Manufacturing Co., of Whippany, N. J., they range from a simple stud, ½" long, to parts possessing intricate profiles, apertures of various shapes and sizes, ribs, lugs, flanges, channels, bosses, fillets, countersinks.

Mount Vernon die casting produces them in quicktime—so clean that machining and finishing operations are cut to a negligible minimum. Result: overall production speeded, unit costs lowered.

Before you okay a manufacturing procedure, give a thought to the important advantages afforded by die casting. Here, at Mount Vernon, our specialized knowledge, long experience and modern facilities will help you profit fully from all of them.



MT. VERNON
DIE CASTING CORP.
MT. VERNON, NEW YORK



One of a series *of messages to help you increase your understanding of business paper advertising, and its effect on your job.*

Why you have a big stake in your company's advertising

NO MATTER WHAT your present job may be, your chances of getting ahead depend on your company's ability to make a fair profit.

As a production man, you have a pretty good idea of how profits are earned. You know that without modern, high-speed production tools, there wouldn't *be* any profits — or any jobs, for that matter. Your cost-per-unit would be so high that you couldn't compete with other manufacturers in your market.

The same thing applies to the *manufacture of a sale!* Without mechanization, the cost of "manufacturing" would be prohibitive.

That's where advertising comes into the picture. Because advertising is simply the assembly-line technique in selling. Just consider the five basic operations involved —

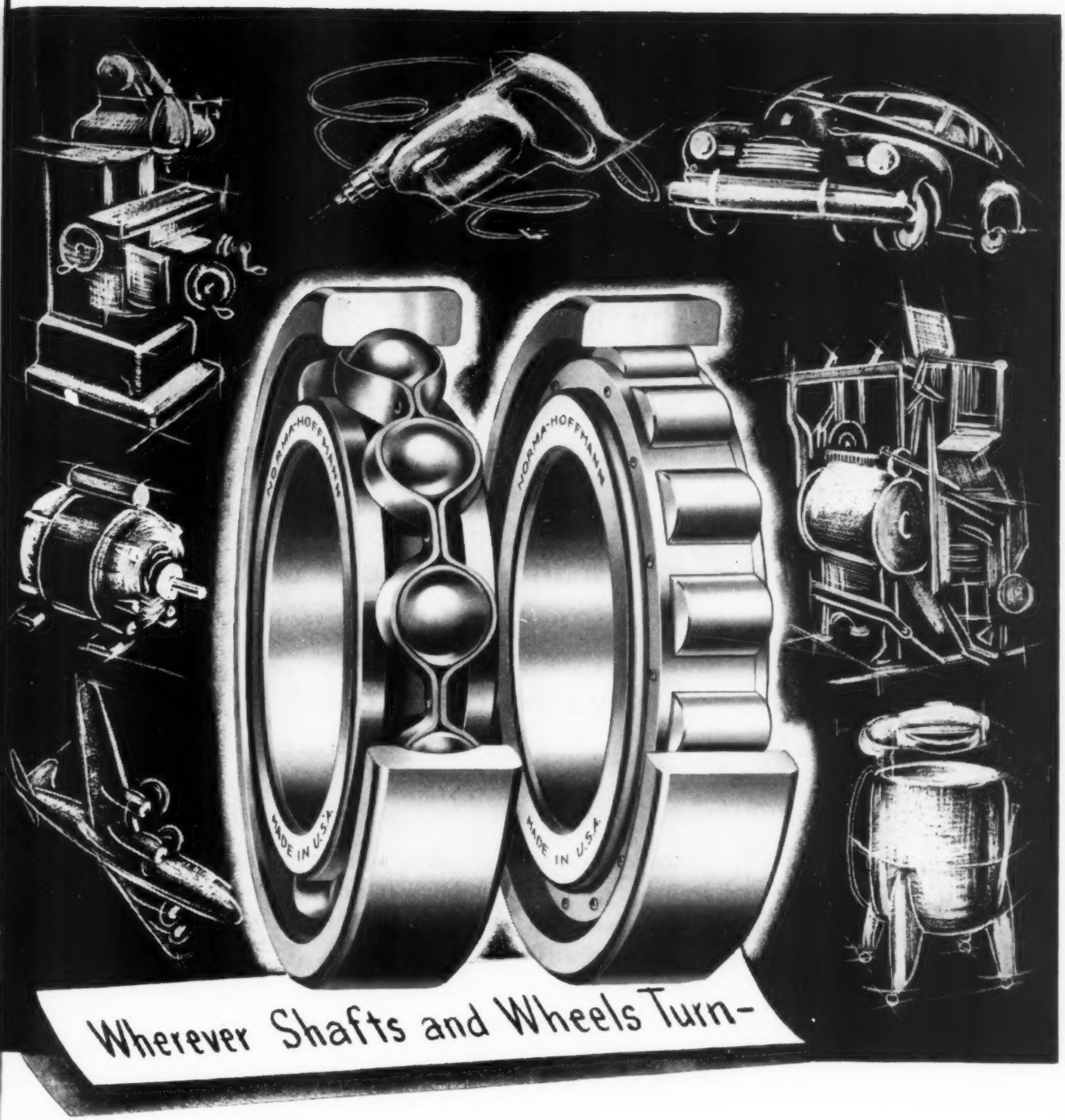
1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

Advertising performs the first three of these jobs. And it performs them *far more economically* than any other means, leaving your salesmen free to concentrate on the two that they alone can do, and do best. In that way, advertising increases your company's chance to earn a profit. And that is why you have a big stake in its *efficient use.*

Where can your company's advertising work at its highest efficiency? Where but in those business papers which are concentrated among your company's best prospects — and *no one else!*

PRODUCT ENGINEERING

is a member of The Associated Business Papers, who have published an interesting folder entitled, "10 ways to measure advertising effectiveness." We'll be glad to send you a copy. And if you'd like reprints of this advertisement (or the entire series) to pass along to others in your organization, just say the word.



Year after Year
Norma-Hoffmann
Precision Bearings
Serve Efficiently

Norma-Hoffmann Engineers, specialists for over 35 years in bearing design and application, are available for consultation.

NORMA-HOFFMANN *Precision* **BEARINGS**
BALL • ROLLER • THRUST

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONNECTICUT

FIELD OFFICES: New York, Chicago, Cleveland, Detroit, Pittsburgh, Cincinnati, Los Angeles, San Francisco, Dallas, Seattle, Phoenix

SYNTHETIC SAPPHIRE *for*

Resistance to Wear

Outlasting hardened steel and cemented carbides 2 to 5,000 times.

Resistance to Friction

Affording very low friction surfaces due to hardness and surface continuity.

Resistance to Heat Distortion

Retention of form at temperatures up to 1,000°C.

Retention of Insulating Properties

Excellent dielectric properties over a wide range of temperatures.

LINDE Synthetic Sapphire is available in a variety of forms. It can be polished by flame or ordinary diamond polishing; it can be formed and bent by flame. Polished sapphire surfaces keep free of dirt and lint, and in many anti-friction applications, need not be lubricated.

The experience that LINDE engineers have in applying sapphire to industrial processes may be of help to you. Call or write the LINDE office nearest you. Get copies of the "Synthetic Sapphire Data Sheet" which gives the complete physical and chemical properties, and the "Synthetic Crystal Stock List" of forms and grades available.

Linde
Trade-Mark

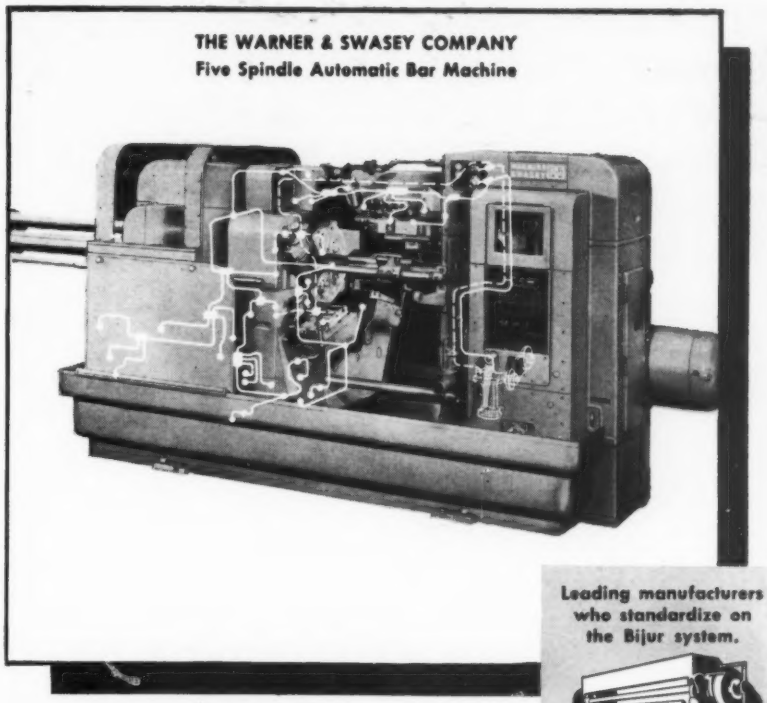
THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The term "Linde" is a trade-mark of The Linde Air Products Company.

884

Your machines run smoother, longer...

THE WARNER & SWASEY COMPANY
Five Spindle Automatic Bar Machine

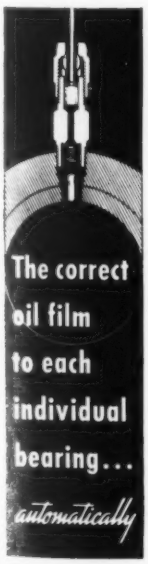


...on bearings oiled by an automatic system of "metered" lubrication

Your machines run smoother, longer and continuously on Bijur-oiled bearings.

Smoother because the correct oil film is constantly maintained by meter-units at the bearings. *Longer* because overall bearing wear is considerably reduced by positive control of oil flow. *Continuously* because a Bijur-equipped machine oils itself while running, eliminating down-time for lubrication.

These factors enable the user to boost production output, cut maintenance costs, and also lengthen the effective life of the machine.



884

Increased Production Output. A Bijur-lubricated machine oils itself while running, doing away with wasteful down-time for lubrication. Daily maintenance time is thus converted into more time for production.

Decreased Maintenance Costs. A Bijur-lubricated machine assures positive control of oil flow, considerably reducing bearing wear. Longer effective bearing life results in less down-time for repairs and maintenance.

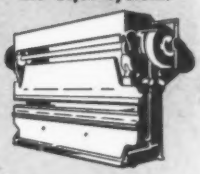
If lubrication is your problem, why not call on the Bijur engineer, or write for "The Travels of Modern Lubrication." This quarterly bulletin shows how leading manufacturers protect performance and maintain production by using Bijur-lubricated machines.

BIJUR

LUBRICATING CORPORATION

LONG ISLAND CITY 1 NEW YORK

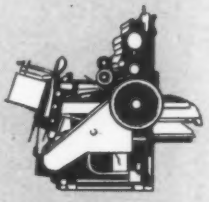
Leading manufacturers who standardize on the Bijur system.



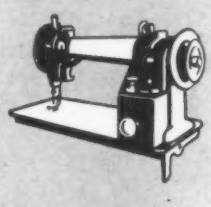
SHEET METAL MACHINERY
Verson "Press Brake"

PACKAGING MACHINERY
Pneumatic Scale "Rotary Top Closing Machine"

FOOD MACHINERY
Baker Perkins "Dough Divider"



PRINTING PRESS
ATF "Chief Offset Press"



TEXTILE MACHINERY
Willcox & Gibbs "Lockstitch Machine"

Like these manufacturers, you too can "be sure with Bijur."

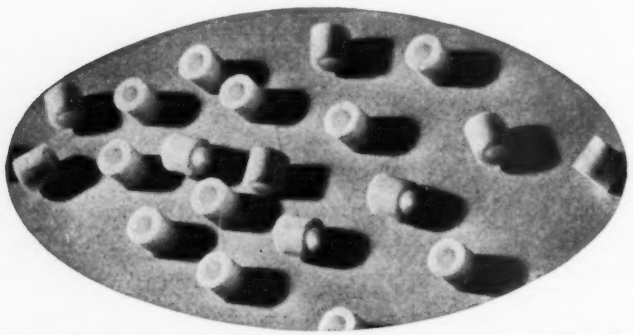
added sales appeal

improved performance

lower cost

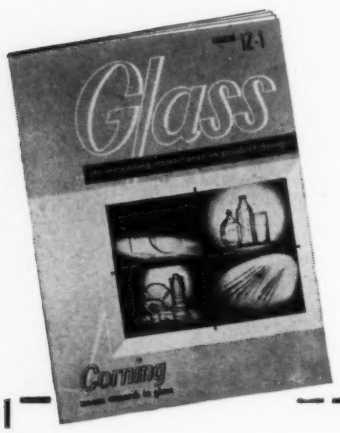
WITH CORNING GLASSES

Corning has a wealth of experience to offer design engineers seeking ways to increase product appeal, improve performance, or lower costs. The example below is typical. Bulletin IZ-1 shows many more.



CORNING* MULTI-FORM INSULATION BEAD

Corning* Multi-form Insulation Beads for electric range elements provide lifetime protection against short circuits from internal carbonization of cooking vapors . . . hence add sales appeal and improve performance. The uniformity of Multi-form glass beads minimizes production time, and the permanence of the glass to metal seal adds years to the life of a range unit.



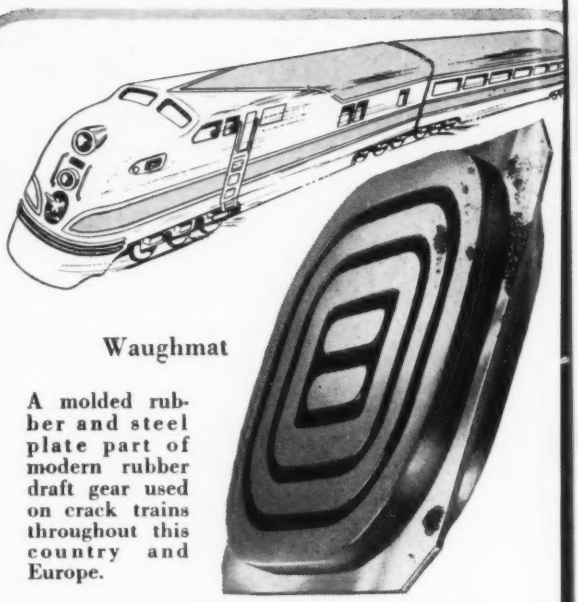
SEND FOR BULLETIN IZ-1 which illustrates other examples, besides listing the properties of all basic Corning glasses to help you in your work.
*T.M. Reg. U.S. Pat. Off.

Sales Offices:
NEW YORK
718 Fifth Avenue
CHICAGO
1470 Merchandise Mart
SAN FRANCISCO
1355 Market Street

CORNING GLASS WORKS, Dept. PE-12
Corning, N. Y.

Please send me a copy of Bulletin IZ-1 "Glass, its increasing importance in product design."

Name .....
Title .....
Firm .....
Street .....
City ..... Zone ..... State .....



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A molded rubber and steel plate part of modern rubber draft gear used on crack trains throughout this country and Europe.

from TRAINS *to* TELEVISION

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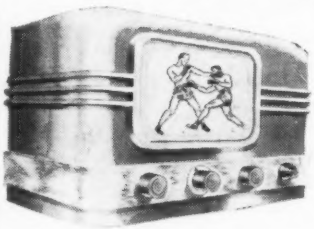
Solid and sponge rubber parts are manufactured to individual specifications of many industries.* May we quote on your rubber requirements.



▲ Sponge rubber frame part of 1949 Model Television Set.

* *REFRIGERATION*
* *SHOES*
* *TELEVISION*
* *RADIO*
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Davidson RUBBER COMPANY
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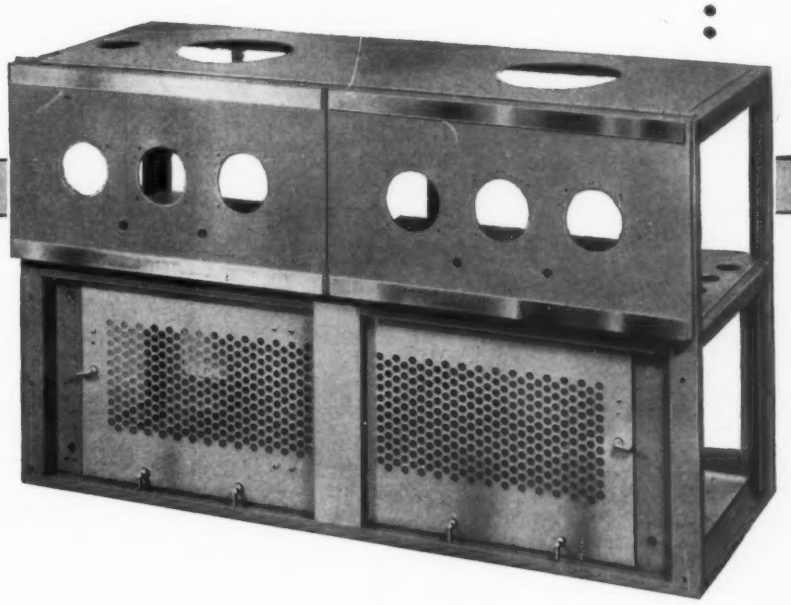
Cabinet Problems? We'll solve them at DAHLSTROM .....

● **Many companies have particular cabinet problems which are solved only by special designing and fabricating. In this field, Dahlstrom is prepared to design and build any cabinet to fit your specialized need. Write Dept. P12 Special Products Division, Dahlstrom Metallic Door Co., Jamestown, N. Y.**



CABINET ASSEMBLY

Upper front panels and lower screen panels have continuous hinges at top. Horizontal inside panels have screen and equipment cutouts.

Size: 50" x 29-1/16" x 18" deep

Material: Steel, frame 11 gauge, panels 13 gauge. Horizontal trim strips, chrome nickel steel in satin finish.

Finish: Heavy copper plate overall. Outside, medium gray enamel. Inside, silver gray enamel. Screen panels, cadmium plated.

DAHLSTROM SPECIAL PRODUCTS

Designing, Engineering and Fabricating of Special Cabinets . . Racks Mouldings . . Control Desks and Panels . . Radio Chassis . . Stampings Enclosures . . Pressed Shapes . . Product Cases . . Special Parts

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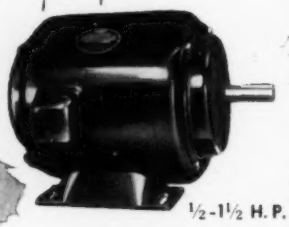
Incomparable

IN PERFORMANCE AND DEPENDABILITY

B-LINE motors match the smooth, quiet operation and attractive appearance of your product, whether it's an office or household appliance, pump, compressor, machine tool or farm machine. They spell "*customer satisfaction*" from every point of view, and give you complete motor satisfaction at lower cost.



½-1½ H.P.

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BRUSH LIFTING MOTOR

With HIGH starting Torque, LOW starting current and quiet operation—single phase general purpose motor for hard starting applications. Simplified brush-lifting centrifugal mechanism has no rods, hinges or pins. The best motor for heavy duty.

B-LINE
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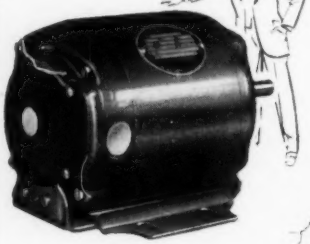
INDUCTION RUN

With INBUILT condenser. New "Simplicity" switch, entirely enclosed—no springs to break or pins to get out of place and cause trouble.

⅙-¾ H.P.



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The rotor actually floats on bearings completely surrounded by large resilient rubber cushions.

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B-LINE
POLYPHASE SQUIRREL CAGE
INDUCTION MOTOR

No brushes or moving parts inside the motor.

⅙-30 H.P.

Send for new descriptive Bulletin No. 5000-B

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Here's the Balanced Pressure design which seals any rotating shaft with minimum frictional heat and power loss! "Sealol" can be engineered to handle

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- **Surface speeds over 10,000 F.P.M.**
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High costs for engine or electric power can cut deeply into your earnings. But you can have the engine or electric power you need at *small* cost with a WITTE Diesel Power Unit or Dieselectric Plant. Thousands in use throughout the world.

Starting and operating on readily available Diesel fuel oil, every WITTE is a *full* Diesel. (Cut-out view shows pre-combustion chamber producing expansion of gases.)

Each WITTE Diesel unit is factory tested 100% for power and performance. There's a size to meet your engine or electric power needs. Write for literature. See how a WITTE can add to your earnings year after year.

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Exceptional Opportunities for DESIGN ENGINEERS

Right now—in the engineering department of the Boeing Airplane Company in Seattle, Washington—are openings for graduate (or the equivalent) aeronautical, mechanical, electrical, and civil engineers. For servo-mechanism designers and analysts there are unusual opportunities.

At Boeing your engineering skill and imagination will be applied to the most advanced military and commercial types of aircraft. The work involves all phases of aircraft design, from the detailing of small parts to the layout of major components, stress analysis, weight control, vibration and flutter analysis, research, development, and all associated engineering work required for completion of the design of the final product.

There's a future for you at Boeing where the current backlog of business totals more than $400,000,000. Outstanding engineering research facilities are available to you. Your associates will be the men who have contributed to Boeing's reputation for leadership in aviation research, design and engineering.

To all these advantages that Boeing offers you, add the fact that living is pleasant in the Pacific Northwest. No extremes of heat and cold. A wide variety of recreation is available the year round—fresh and salt water sailing and fishing, skiing, golf, and mountain climbing.

Similar openings are available in the Boeing-Wichita, Kansas plant. Inquiries indicating a preference for Wichita assignment will be referred to the Wichita Division.

For an illustrated brochure, "As the Twig is Bent," on Boeing engineering, and additional information about the opportunities discussed here, write "Personnel Office, Engineering Division, Boeing Airplane Company, 7754 E. Marginal Way, Seattle 14, Washington."

ANSWERING YOUR QUESTIONS

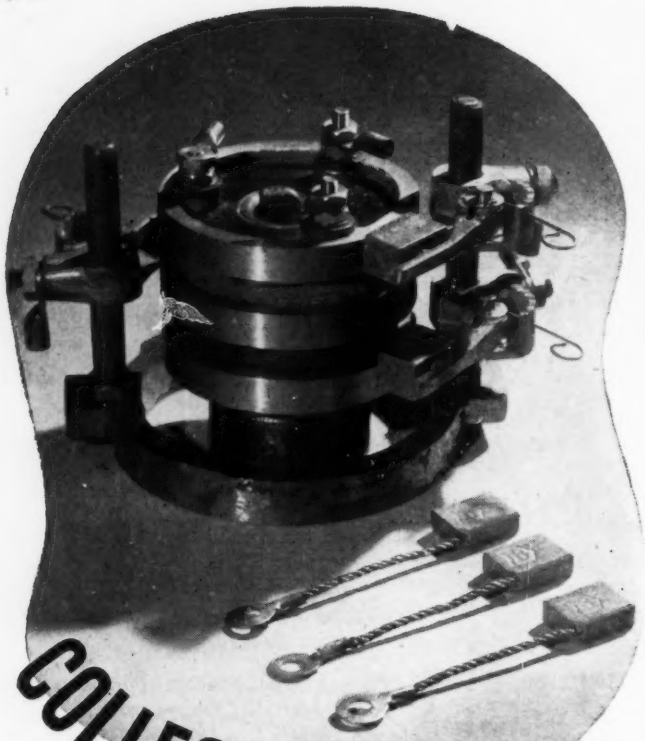
1. What about housing? *Recent new employees have had no difficulty. Our Personnel Unit will give you all possible assistance in finding suitable housing.*
2. What are opportunities for advancement? *Opportunities in all engineering units are virtually unlimited and depend primarily on training, ability and application of the individual.*
3. Does Boeing need men with advanced training? *Definitely yes. Men with advanced training and degrees are very much in demand and command correspondingly higher starting wages.*
4. What are the working hours? *Normally an eight hour day and five day week—8:00 to 4:30 daily.*
5. Is there a formal school or training program? *New engineers are normally placed in a group commensurate with their qualifications. A short training program carried on concurrently with design assignments is given for familiarization with Boeing procedures and practices.*

ADDED ADVANTAGES OF WORKING AT BOEING

1. Two weeks vacation with pay.
2. Ten days sick leave per year — if necessary.
3. Low cost group medical plan.
4. Low cost accident and health insurance.
5. Unusually attractive group life insurance.

For the Air Force, Boeing is building the B-50 bomber, XB-47 jet bomber and C-97 transport; for the Army, the L-15 liaison plane; and for six major airlines, the twin-deck Boeing Stratocruiser.

BOEING



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WELCO Collector Rings are made in all sizes to carry currents of 5 to 200 amperes. Two to twelve rings can be furnished on one stub complete with brush holders, brushes, studs for supporting the brush holders and stud rings. The collector rings can be assembled as a unit on one hollow tube with threads on one end and insulation bushing on the opposite end. The brush holders carrying the current are made of brass. The collector rings are made of hard bronze material. Bakelite insulation is used.

Welco Collector Rings are custom-built to fit the special design and functional requirements of your machines or equipment. A limited number of standard types are available. Send us your blueprints and we will design for you the collector rings that are functionally correct.

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EXPERIMENTAL STRESS ANALYSIS SYMPOSIUM

A 16-page insert, featuring histories of applications of experimental stress analysis methods which resulted in design improvements, appeared in the December 1946 issue of *Product Engineering*.

For those who would like copies of this insert for distribution among their technical staffs, a limited supply of reprints is available at 15c each.

PRODUCT ENGINEERING

330 WEST 42ND ST.
NEW YORK 18, N. Y.

HOW you and your employees can reduce this inflationary gap

With proper guidance from top management, the nation's workers can powerfully attack inflation at its source.

One way, of course, is by increasing production. But production of most goods already has been pushed to maximum! The other approach is to reduce the volume of dollars that can be used to bid up prices on scarce goods.

There's no more effective tool for this job than the Payroll Savings Plan for the regular purchase of U. S. Security Bonds. Via this plan, 5.5 million wage earners are investing over 8% of their pay—over 100 million dollars per month—in Bonds.

What Is the Status of the Plan in Your Company?

In companies where top management backs the Plan, 35% to 50% of the employees participate, and the average total Bond-holding is $1200 per family. If these figures are above those for your employees, it is apparent that the Plan needs reinvigoration by your personal sponsorship.

Benefits Accrue to the Nation and to Your Company

Every Bond dollar that is built up in the Treasury is used to retire a dollar of the national debt that is potentially inflationary. Every Bond held means fewer dollars to go to market to bid up prices on scarce goods. In addition, dollars invested in Bonds are building future purchasing power. All these factors contribute to the security of the national economy—including your business.

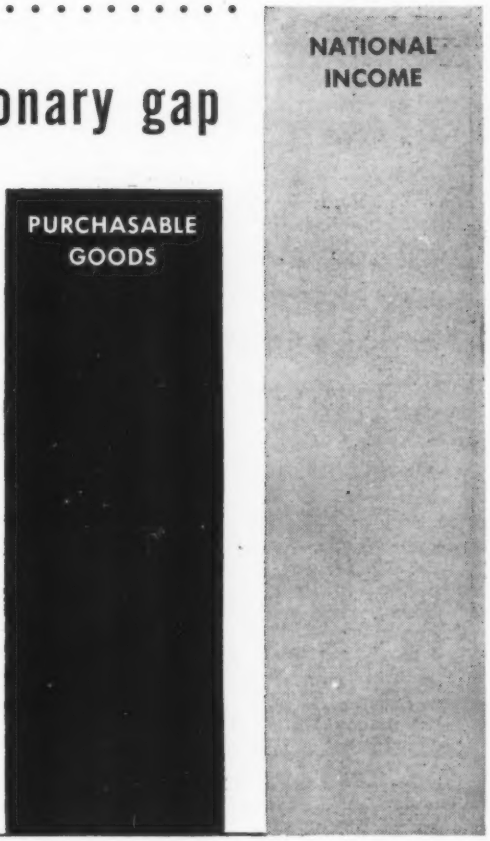
Bonds build security for individuals, because every $3 invested pay $4 at maturity.

Moreover, in 19,000 companies operating the Payroll Savings Plan, employees have proved to be more contented. Worker production has increased, absenteeism has decreased—even accidents have been fewer!

Management's Role Is Vital

Even with all its benefits, the Payroll Savings Plan requires sponsorship by top management to keep employees *aware* of the benefits. That's why the Treasury Department has prepared a kit of materials especially for you to distribute among specific key personnel. Be sure to get and use your kit—for the security of your company and your country!

For any help you want, call on your Treasury Department's State Director, Savings Bonds Division.



The Treasury Department acknowledges with appreciation the publication of this message by

PRODUCT ENGINEERING

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AIRCRAFT DESIGNERS

and specialists in all phases of aircraft engineering, for work on military projects. Experience in fields other than aircraft engineering may be adaptable. Please include summary of experience in reply.

Engineering Personnel Office
NORTH AMERICAN AVIATION, INC.
Municipal Airport
Los Angeles 45, Calif.

STRESS ANALYSTS

Stress Analysts: Graduate in mechanical engineering or physics with five to ten years experience in theoretical or experimental stress analysis, preferably on pressure vessels and heat exchange equipment. Knowledge of thermal stresses desirable. Excellent opportunity for qualified man in new Research and Development Department Laboratory. Write, giving resume of education and experience.

THE BABCOCK & WILCOX COMPANY
Research & Development Department,
ALLIANCE, OHIO

GRADUATE MECHANICAL ENGINEER

With several years of laboratory experience for research and development work in excellently equipped mechanical laboratory. Experience in the design and testing of all types of small fans and filters desirable but not essential. Outline your experience and qualifications fully. Interviews may be arranged. Location—Northeastern Ohio.

P-6635, Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

WANTED
MACHINE TOOL DESIGNERS

THE MONARCH MACHINE TOOL COMPANY
Sidney, Ohio

WANTED
DESIGN ENGINEER

Graduate mechanical engineer with good experience in the design of heavy machinery such as excavating machinery, cranes, marine auxiliaries or similar. Must be qualified by education and experience to assume responsible charge of a group of about six draftsmen-detailers and qualified for rapid promotion to position of assistant chief engineer. Permanent position for experienced man with medium size manufacturer established sixty years, location Middle Atlantic. All replies in confidence. Address

P-7038, Product Engineering
330 West 42nd Street, New York 18, N. Y.

ASSISTANT CHIEF DESIGN ENGINEER

Large Midwestern Company requires the services of a Product and Design Engineer with industrial art experience, to develop major home appliances and equipment.

Position requires thorough knowledge of pressed metal fabrication, mechanical equipment, porcelain and synthetic enameling.

Replies held in strictest confidence. Our organization knows of this advertisement.

P-7163, Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

PRODUCT DESIGNER MACHINE DESIGNERS

DESIGN AND DRAFTING POSITIONS open for a PRODUCT DESIGNER who has had experience in the Mechanical Design of small, complex machines—preferably in the office equipment field—and for MACHINE DESIGNERS experienced in the design of heavy duty equipment, preferably in the field of printing or paper processing. Future advancement dependent upon capabilities demonstrated.

Please write:
Employment Manager
THE STANDARD REGISTER COMPANY
Campbell & Albany Streets, Dayton, Ohio.

TECHNICAL AND RESEARCH ENGINEER

Excellent opportunity for creative and research minded engineer with well established rubber company where his new ideas, inspirational and organizational qualifications will permit him to work with large group of technical and development engineers. This requires above average engineer. Age 30 to 40. Furnish complete information in first letter. Replies held in strict confidence.

P-7105, Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

WANTED
General Superintendent

to take charge of plant manufacturing small gears and precision parts. Must have engineering and practical shop background and be familiar with all phases of manufacturing, inspection and heat treating. Plant employs 250 to 300 people and is located in Middle West. Good opportunity for right man. Give age, nationality and full details regarding experience and training, also give salary expected.

ADDRESS
P 7199 Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

REPLIES (Box No.): Address to office nearest you
NEW YORK: 330 W. 42nd St. (18)
CHICAGO: 520 N. Michigan Ave. (11)
SAN FRANCISCO: 68 Post St. (4)

POSITIONS VACANT

WANTED—ENGINEERS—Expanding southern industry has openings for mechanical engineer for machine design, mechanical and process development work. Please give in first letter full details of education, age, experience, qualifications, references, availability, and salary desired. P-6735, Product Engineering.

RESEARCH ENGINEERS: With degree in Mechanical Engineering or Physics and five to ten years experience in research or development work. For applied research on the flow of water, steam and air; metals under simulated service conditions; heat transfer; experimental stress analysis; all as applied to steam boilers and related equipment. Unusual opportunity for men in new research and development laboratory. The Babcock and Wilcox Co., Research & Development Department, Alliance, Ohio.

ENGINEER FOR design and installation of steam and electrical equipment in new plant of expanding industry. After construction, man selected will have possible opportunity as plant engineer. Complete information required in first letter. All details confidential. P-6783, Product Engineering.

RESEARCH DESIGNER: For the design of experimental apparatus. Each apparatus is designed individually to provide the conditions desired for the specific problem. These problems deal with applied research on heat transfer; metals under simulated service conditions; flow of water, steam and air, experimental stress analysis. Degree in engineering or physics with about five years experience in research or development is desirable. The Babcock and Wilcox Co., Research & Development Department, Alliance, Ohio.

WANTED: MECHANICAL Engineer—Graduate or equivalent for automatic machine design and development. Must have proven flair for this work. Located in New Jersey, near Somerville. Send full resume of past positions and salaries. P 7110, Product Engineering.

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SALARIED POSITIONS $3,500-$35,000. If you are considering a new connection communicate with the undersigned. We offer the original personal employment service (38 years recognized standing and reputation). The procedure, of highest ethical standards, is individualized to your personal requirements and develops overtures without initiative on your part. Your identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 268 Dun Bldg., Buffalo 2, N. Y.

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Old established manufacturer of nationally advertised jewelry items, can use services top notch executive, 40 or over, well seasoned, with top engineering ability and actual experience in modern tool and die designing and processing. Manufacturing of light stampings from non-ferrous, copper alloyed metals. Qualified to correlate engineering functions. Splendid opportunity Salary open. Beautiful suburban area, midwest location. Submit recent photo with resume.

P-7159, Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

ENGINEERS
DESIGN — TEST — EXPERIMENTAL

Midwestern manufacturer of 2-cycle engines has openings for ambitious engineers. Experience in 2-cycle engines and/or magneto ignition desirable.

P 6955 Product Engineering
520 North Michigan Ave., Chicago 11, Ill.

EMPLOYMENT SERVICE

SALARIED PERSONNEL $3,000-$25,000. This confidential service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer Jennings, Dept. H, 241 Orange St., New Haven, Conn.

DESIGN DRAFTSMAN: Old established Philadelphia manufacturer has opening for man with considerable experience and creative ability on design and development small mechanisms for mass production. Experience on small stampings, plastics and die castings, as used in automotive accessories, household appliances, etc., very necessary. Give all details in first letter, which will be treated confidentially. PW 7090, Product Engineering.

POSITIONS WANTED

AVAILABLE: TOOL Engineer, designer, machine design. Prefer central state or west coast. 12 years varied experience. Interested in chief draftsman, or position leading to same. PW 6971, Product Engineering.

ENGINEER EXECUTIVE. Registered Engineer with 16 years experience in Structural, Sheet Metal, and Mechanical work. Experienced in organizing and supervising an Eng. Dept. Prefer position with medium size manufacturing plant in Central or Mid-West State. Complete resume on request. PW 7210, Product Engineering.

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Copy must be received by December 17th to appear in the January issue.

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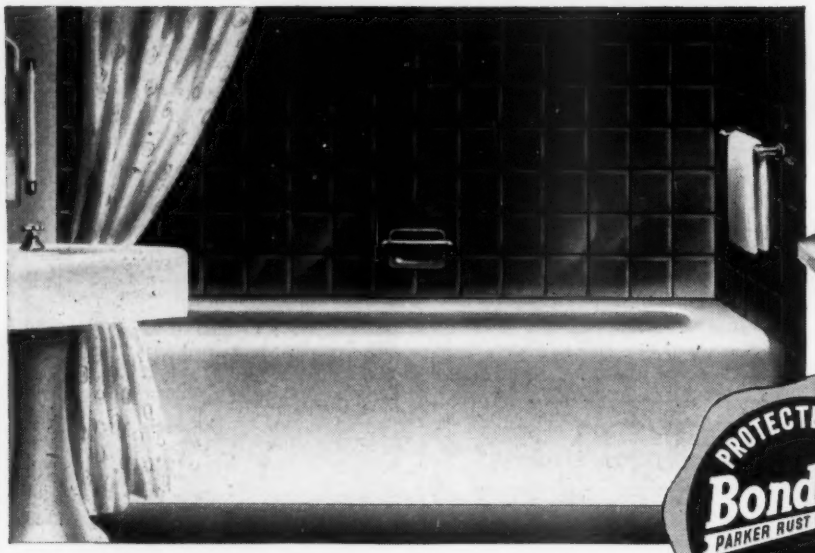

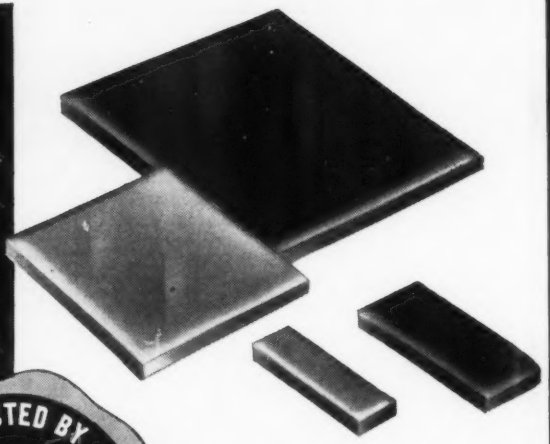

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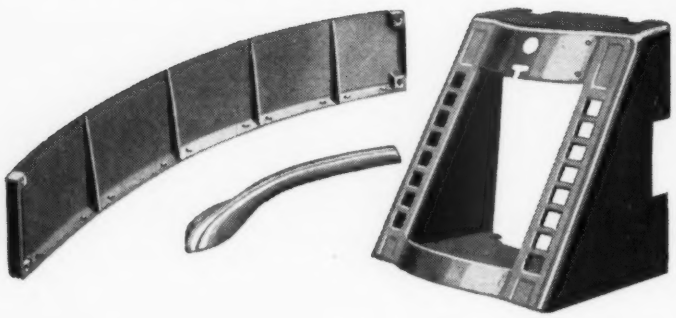

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INDEX OF *Products Advertised* IN THIS ISSUE

MATERIALS

Adhesives 276
Aluminum Alloys.10-11, 41, 53, 183, 198
Bimetal 78, 300
Brass..66-67, 196-197, 218, 263-264, 311
Bronze....66–67, 196–197, 263–264, 286
Carbon 310
Copper Alloys.....66–67, 218, 263–264 294, 311
Felt 275
Fibre 200
Friction Materials 158
Glass.....237, 258, 274, 330
Graphite .....4th Cover, 14–15
Jewel, Synthetics 194, 328
Laminated Metals 58
Leather 283
Magnesium Alloys 226, 287
Molybdenum Alloys 216
Nickel Alloys..2nd Cover, 50, 52, 66–67 171, 263–264
Plastics..12, 20–21, 22–23, 27, 49, 64C 236, 251, 267, 281–282
Plastics, Laminated.....49, 200, 274
Powdered Metals 321
Resins 12, 56
Rubber & Synthetics..31, 56, 178, 211 216, 265, 330
Silicones 8, 176
Stainless Steel.....50, 213, 295, 323
Steel....36, 50, 60-61, 64A, 71, 160, 235 299, 315
Zinc 75

STRUCTURAL PARTS

Castings..32, 42, 196–197, 212, 240, 287 302, 305, 308
Die Castings 75, 76, 325
Forgings 212, 300
Metal Powder Parts..... 321
Stampings 64B, 194, 231, 255
Tubing..36, 77, 180 201, 227–228, 230 239, 262, 300, 303
Wire 58, 180, 202, 255

FINISHES

Paints & Lacquers.....167, 258
Rust Proofing 268, 338

MECHANICAL PARTS

Accumulators 64
Adhesives 276
Balls 182, 314
Bearings, Ball, Roller, and Needle 4th Cover, 9, 13, 30, 32B, 54, 70, 189 202, 232, 248, 250, 256, 280, 285, 289 290, 292, 301, 312, 327, 340
Bearings, Sleeve 254, 286, 316
Bellows 34
Belts.....13, 28–29, 35, 64F, 265, 309
Bolts Nuts, Screws and Rivets..6, 16 44, 55, 73, 74, 173, 177, 185, 206–207 208, 222, 236, 266 276, 290, 292, 319 320, 334, 342
Brushes 258
Chains 13, 64F, 204-205
Clamps 304
Clutches..46, 80, 257, 284, 292, 294, 318
Containers 214
Counters 17
Couplings, Flexible.....176, 249
Couplings, Hose & Tube..... 63
Engines...224, 304, 312, 314, 318, 332
Fastenings...6, 16, 44, 55, 73, 74, 173 177, 185, 206-207, 208, 222, 236, 266 276, 290, 292, 319, 320, 334, 342
Filters 72, 291
Gears..62, 163, 184, 192, 249, 256, 268 296, 312
Hydraulic & Pneumatic Equipment..13, 64, 80, 243, 244, 247, 253 273, 278, 279, 307, 308, 324
Joints 300, 317
Locks, Hinges 298
Lubricating Equipment ..181, 193, 329
Mountings 219
Name Plates 179
Packing, Gaskets, Seals...4, 14-15, 39 51, 158, 193, 253, 271, 275, 283, 297 306, 332, 344
Piping 227–228
Plastic Machinery 203
Pumps..28–29, 215, 225, 243, 244, 273 296, 298, 302, 324
Rings..14–15, 48, 180, 223, 261, 334
Shafts 182, 314
Sheaves & Pulleys.....28-29, 35
Shims 190
Silicones 8, 176
Speed Reducers & Motor Reducers 13, 221, 249, 306
Springs.....68, 236, 238, 248, 255
Tanks 233
Testing Equipment 195, 293
Thermostats 26, 78, 300, 310
Tires 216
Transmissions..3rd Cover, 28–29, 80 215, 244, 296
Valves & Fittings...165, 215, 234, 238 243, 244, 253, 272, 273, 294, 307, 318 324
Vibration Dampers 219, 293
Wheels & Casters..... 290
Wire Cloth 43

ELECTRICAL PARTS

Assemblies 186
Brakes 46, 187
Contacts 78
Controls & Control Equipment... 2 18–19, 28–29, 40, 57, 174–175, 217 245–246, 270, 279, 284, 288
Electronic Equipment.....2, 40, 186 188, 260
Generators 189, 256
Heating Units.....277, 302
Instruments 183, 288
Insulators 33, 191, 220, 330
Lamps 65
Magnets 45
Magneto 47, 189
Motors..3rd Cover 24–25, 28–29, 32A 37, 59, 64D–64E, 187, 189, 215, 221 241, 252, 256, 259, 269, 272, 322
Rectifiers 38
Transformers 187
Wire & Cable 156, 191
Wiring Accessories 260, 292

DRAFTING ROOM EQUIPMENT AND SUPPLIES

69, 154, 186, 188, 199, 242, 276, 284, 304

FABRICATING METHODS AND SERVICES

Assembling.....53, 180, 268, 298
Drawing 53
Forming.....53, 71, 169, 248 298
Grinding 247, 278
Hardening 313
Milling 298
Molding..12, 20–21, 22–23, 27, 49, 64C 203, 236 251, 267, 268, 281–282, 331
Shearing 238
Spinning 53, 184
Stamping.....53, 194, 238, 248 268 298, 331
Welding 229, 320

ENGINEERING AND PRODUCTION SERVICES

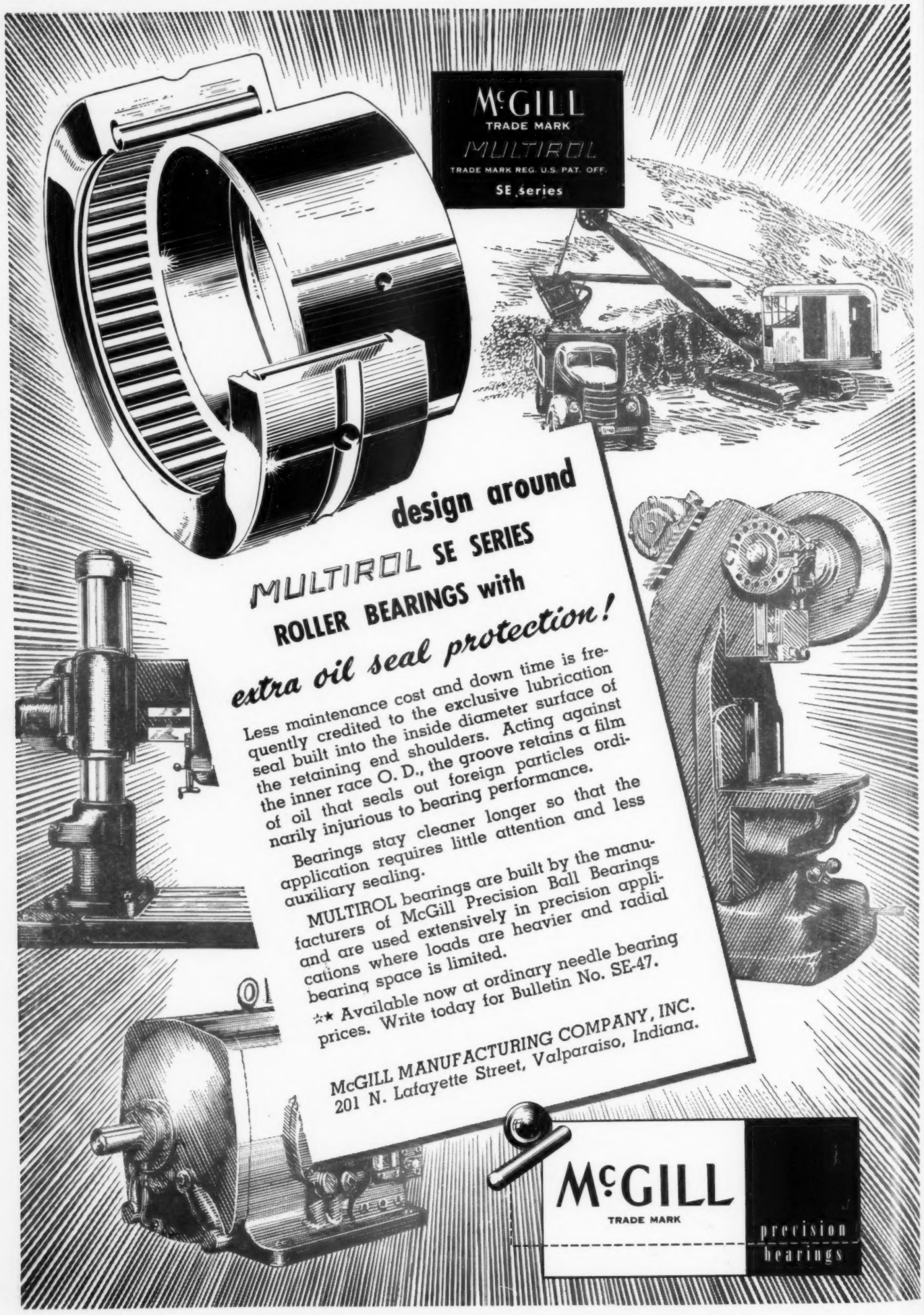
188, 333, 336

BOOKS

224

TRANSPORTATION

272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ADVERTISERS INDEX

Accurate Spring Mfg. Co..... 236
Advance Paint Co..... 167
Aetna Ball & Roller Bearing Co... 256
Ahlberg Bearing Co..... 248
Aircraft-Marine Products Co..... 191
Air Express Division of Railway Agency Express 272
Allegheny Ludlum Steel Corp.... 323
Allen Mfg. Co..... 222
Allied Research Products, Inc.... 268
Allis-Chalmers Mfg. Co.....28-29, 35
Allis-Chalmers Mfg. Co. (Tractor Div.) 312
Allmetal Screw Products Co. Inc.. 236
Aluminum Co. of America-Fabricator 10-11
Aluminum Co. of America-Fasteners 276
Aluminum Goods Mfg. Co..... 183
American Chain & Cable Co. Inc.. 202
American Felt Co..... 275
American Hard Rubber Co..... 178
American Insulator Corp..... 236
American Magnesium Corp..... 287
American Metal Hose Branch, American Brass Co..... 63
American Nickeloid Co..... 171
American Roller Bearing Co..... 290
American Screw Co.....55, 73
Apex Machine & Tool Co..... 317
Arkwright Finishing Co..... 284
Armstrong Cork Co..... 39
Arrow-Hart & Hegeman Electric Co. 270
Automatic Steel Products, Inc.... 284

Bakelite Corp. 27, 281-282
Baldt Anchor, Chain & Forge Div. of The Boston Metal Co..... 212
Baldwin Locomotive Works..... 195
Bantam Bearings Div. Torrington Co. 32B
Barnes Co., Wallace Div. Associated Spring Co..... 68
Barnes Gibson Raymond Div., Associated Spring Co..... 238
Bath Co., Cyril..... 169
Beryllium Corp. 294
Bethlehem Steel Corp..... 71
Bijur Lubricating Corp. 329
Blackhawk Mfg. Co. 273
Boeing Airplane Co..... 333
Boston Gear Works..... 202
Bound Brook Oilless Bearing Co.. 321
Brass & Bronze Ingot Institute.196-197
Bridgeport Brass Co.....66-67
Briggs & Stratton Corp..... 224
Bristol Co. 319
Brown Brockmeyer Co..... 332
Brown Instrument Company..... 288
Brown & Sharpe Mfg. Co..... 225
Bruning Co., Inc., Charles..... 69
Bundy Tubing Co..... 262
Bunting Brass & Bronze Co..... 286

Camcar Products Co..... 55
Carnegie-Illinois Steel Corp.....60-61
Carpenter Steel Co., Alloy Tube Div. 77
Cash Valve Mfg. Corp., A. W.... 238
Central Screw Co..... 55
Century Electric Co..... 269
Chace Co., W. M..... 300
Chain Belt Co.....201-205
Chapman Valve Mfg. Co..... 313
Chase Brass & Copper Co., Inc... 311
Chicago Rawhide Mfg. Co..... 283
Clare & Co., C. P..... 217
Clifford Mfg. Co..... 34
Climax Molybdenum Co..... 216
Cold Metal Products Co..... 295
Columbia Steel Co.....36, 60-61
Commercial Shearing & Stamping Co. 238
Consolidated Molded Products, Inc. 267
Continental-Diamond Fibre Co... 200
Continental Screw Co..... 55
Corbin Cabinet Lock Co., Div. Amer. Hdwe. Corp..... 298
Corbin Screw Div. of American Hdwe. Corp. 55
Corning Glass Works..... 330
Crane Company 165
Cuno Engineering Corp..... 72
Cuyahoga Spring Co..... 248

Dahlstrom Metallic Door Co..... 331
Davidson Rubber Co..... 330
Dayton Rogers Mfg. Co..... 188
Dayton Rubber Manufacturing Co. 265
Delco Products Div., Gen. Mtrs. Corp. 259
Denison Engineering Co..... 302
Diefendorf Gear Corp..... 268
Dow Chemical Co..... 226
Dow Corning Corp..... 176
Driver-Harris Co. 260
Du Pont de Nemours & Co., Inc., Neoprene, E. I..... 31
Durez Plastics & Chemicals, Inc.. 12

Earle Gear & Machine Co..... 256
Eastman Kodak Co..... 199
Eaton Mfg. Co., Foundry Division 32
Eaton Mfg. Co.-Reliance Spring Washer Div. 48
Economy Blue Print Products Co. 304
Edison Inc., Thomas A..... 188
Elastic Stop Nut Corp. of America 177
Elco Tool & Screw Corp..... 55
Electric Auto-Lite Co.....64C, 156
Electric Boat Co., Electro Dynamic Div. 32A
Electric Specialty Co..... 256
Electro Dynamic Div., Electric Boat Co. 32A
Electrol. Inc. 307
Electro Machines, Inc..... 272
Excello Corp. 247

Fansteel Metallurgical Corp..... 38
Fawick Airflex Co..... 257
Federal Bearings Co., Inc..... 70
Federal-Mogul Corp. (Equipment) 254
Foote Bros. Gear & Machine Corp. 62
Formica Insulation Co..... 248

Garlock Packing Co..... 306
Gates Rubber Co..... 309
Gear Grinding Machine Co..... 278
General Controls Co..... 272
General Electric Co., Apparatus Dept. 18-19, 24-25, 37
General Electric Co.-Chemical Dept., Metallurgy Div..... 45
General Electric Co., Lamps Dept. 65
General Electric Co., Chemical Dept., Sillicones 8
General Plate Co..... 58
General Tire & Rubber Co..... 216
Gerity-Michigan Corp. 76
Gerotor May Corp..... 324
Gits Bros. Mfg. Co..... 193
Globe Steel Tubes Co..... 303
Goodrich Chemical Co., B. G., (Hycar) 56
Goodrich Co., B. F. (Rivnut)..... 6
Gray Iron Founders' Society Inc.. 305
Great Lakes Div., National Steel Corp. 160
Greene Mfg. Co., Inc..... 268
Greer Hydraulics, Inc..... 64

Hannifin Corporation 308
Harper Co., H. M..... 55
Hartford Steel Ball Co..... 314
Hercules Powder Co., Inc..... 251
Hilliard Corp. 318
Holo-Krome Screw Corp..... 208
Hoover Ball & Bearing Co..... 301
Houghton & Co., E. F..... 271
Howell Electric Motors Co..... 252
Hunt & Son C. B..... 234
Hussey & Co., C. G..... 218
Hyatt Bearings Div., Gen. Mtrs. Corp. 54

Imperial Pencil Tracing Cloth.... 276
International Nickel Co., Inc..... 2nd Cover
International Nickel Co., Inc., (Monel) 52
Interstate Mfg. Corp..... 292

Jack & Heintz Precision Industries Inc. 189
James Gear Mfg. Co., D. O..... 249
Janette Mfg. Co..... 306
Johns Manville Corp. Packing.... 344
Johnson Bronze Co..... 316
Jones & Laughlin Steel Corp..... 299

Keuffel & Esser Co..... 242
Kinney Mfg. Co..... 292
Koh-I-Noor Pencil Co., Inc..... 185
Koppers Co., Inc..... 276
Koppers Co., Inc.-Plastics Div...22-23
Kopp Glass Inc..... 237

Laminated Shim Co., Inc. (Laminum) 190
Lamson & Sessions Co..... 55
Lebanon Steel Foundry Co..... 212
Linde Air Products Co..... 328
Linear, Inc. 297
Link-Belt Co. 9, 13

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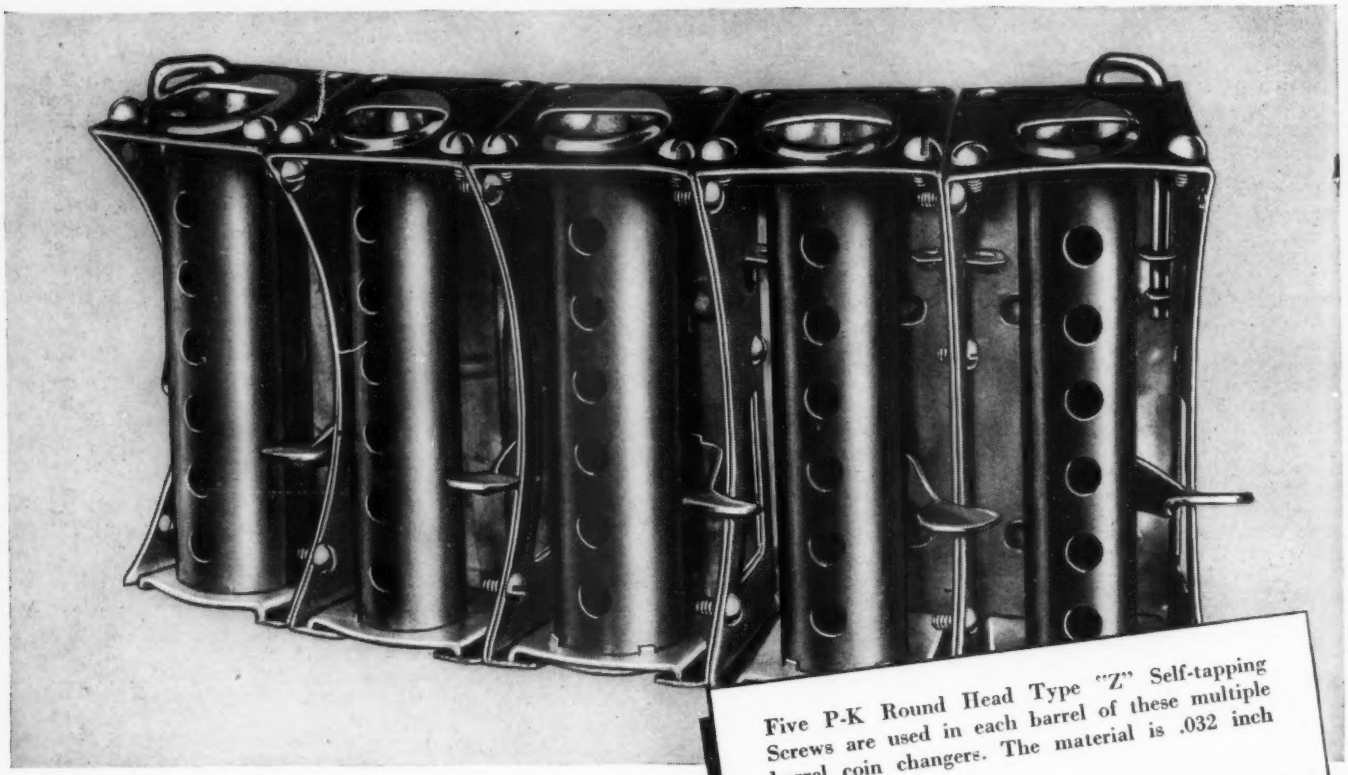
MAKES THE "RIGHT CHANGE"...SAVES 40% IN WORK-HOURS

... avoids tapping 22 holes



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With today's high wages, a 40% saving in assembly work-hours is a change well worth making. And that's why Meyer & Wenthe, Inc. switched to P-K Self-tapping Screws in the assembly of their barrel coin changer.

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The odds are with you . . . call a P-K Assembly Engineer and see if you are one of the "lucky seven". If you prefer, mail assembly details for recommendations. Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

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ADVERTISERS INDEX

Lombard Governor Corp..... 296
Lord Mfg. Co..... 219
Lukens Steel Co. (Clad Steel)... 50
Lukens Steel Co. (Flanging & Pressing) 44

McGill Mfg. Co., Inc..... 340
McGraw-Hill Book Co. Inc..... 224
MB Mfg. Co., Inc..... 293
Mahon Co., R. C..... 229
Makepeace Co., D. E..... 180
Mallory & Co., Inc., P. R.....2, 40
Marlin-Rockwell Corp. 289
Martin-Hubbard Corp. 188
Master Electric Co., Speedmaster 3rd Cover
Meehanite Metal Corp..... 42
Mercury Clutch Div., Automatic Steel Pdts. Inc..... 284
Meyercord Co. (Name Plate Div.) 179
Michigan Tool Co..... 163
Milford Rivet & Machine Co..... 55
Miniature Precision Bearings Inc. 312
Minneapolis-Honeywell Regulator Co. 284
Monsanto Chemical Co.....20-21
Morganite, Inc. 261
Morse Chain Co..... 80
Mt. Vernon Die Casting Corp..... 325

National Acme Co. 279
National Bearing Div., American Brake Shoe Co. 285
National Lock Co. 55
National Lock Washer Co., (Kantlink) 173
National Motor Bearing Co. Inc... 51
National Screw & Mfg. Co..... 55
National Steel Corp.....64A, 160
National Tube Co. 36
New Departure Div. of Gen Motors Corp. 30
New England Screw Co. 55
New Hampshire Ball Bearings Inc. 292
New Jersey Zinc Co. 75
Nicholson & Co., W. H. 318
Nikoh Tube Co. 227–228
Norgren Co., Inc., C. A..... 181
Norma-Hoffman Bearings Corp... 327

Ohio Precision Casting Co..... 308
Ohio Rubber Co. 211
Ohio Seamless Tube Co. 230
Ohmite Manufacturing Co.... 245–246
Oilgear Co. 215
Onan & Sons, Inc., D. W.....314, 318
Owens-Corning Fiberglas Corp... 220 274
Osalid Products Div., General Aniline & Film Corp. 154

Packard Electric Div., General Motors 241
Page Steel & Wire Div., Amer. Chain & Cable Co. Inc..... 202
Parker-Kalon Corp.....55, 266, 342
Parker Rust Proof Co..... 338
Pawtucket Screw Co. 55
Perkins Machine & Gear Co..... 192
Permanente Metals Corp. 198
Pesco Products Co., Borg-Warner Corp. 243
Pheoll Manufacturing Co. 55
Phillips Screw Manufacturers.... 55
Pittsburgh Plate Glass Co., Brush Div. 258
Precision Tube Co. 201
Progressive Mfg. Co. 290
Pure Carbon Co., Inc. 310

Raybestos-Manhattan Inc., Equipment, Sales Division..... 158
Raymond Mfg. Co., Div. Associated Spring Co. 255
Reading Screw Co. 55
Redmond Co., Inc. 59
Revere Copper & Brass Inc....263–264
Reynolds Metals Co., Aluminum Div. 41
Reynolds Metals Co., Industrial Parts Div. 53
Reynolds Wire Co. 43
Robertshaw-Fulton Controls Co... 310
Rockford Clutch Div., Borg-Warner 294
Rockford Screw Products Co..... 55
Roehr Products Co. 300
Roland Teiner Co. 184
Rollway Bearing Co., Inc..... 250
Rotary Seal Co. 4
Russell Burdsall & Ward Bolt & Nut Co. 55

SKF Industries, Inc. 280
Safety Socket Screw Co. 320
Saginaw Products Corp..... 290
Sandvik Steel, Inc. 235
Scaife Co. 233
Scintilla Magneto Div., Bendix Aviation Corp. 47
Scovill Mfg. Co. Industrial Fasteners 185
Scovill Mfg. Co. 55
Seaboard Screw Corp. 55
Sealol Corp. 332
Sewall Mfg. Co., E. B. 184
Shakeproof Inc. 55, 206–207
Sharon Steel Corp. 213
Sier Bath Gear & Pump Co..... 312
Skinner Electric Valve Div., The Skinner Chuck Co. 294
Skinner Purifiers Div., Bendix Aviation Corp. 291
Southington Hardware Mfg. Co... 55
Spencer Thermostat Co. 26
Standard Locknut & Lockwasher Co. 292
Standard Pressed Steel Co. 74, 334
Standard Tube Co. 239
Steel Co. of Canada, Ltd. 55
Stephens-Adamson Mfg. Co..... 232
Sterling Bolt Co. 55
Stewart Mfg. Corp., F. W..... 182
Stokes Machine Co., F. J..... 203
Stow Mfg. Co. 314
Strom Steel Ball Co. 182
Stronghold Screw Products, Inc... 55
Sundstrand Machine Tool Co..... 244
Superior Steel Corp. 315

Taylor-Winfield Corp. 320
Tennessee Coal, Iron & Railroad Co. 60–61
Thomas Flexible Coupling Co..... 176
Torrington Co., Bantam Bearings Div. 32B
Torrington Co. 298
Tourek Mfg. Co., J. J..... 300
Transue & Williams Co. (Stamping Div.) 231
Tuthill Pump Co. 298

Union Carbide & Carbon Corp... 27 281–282, 328
Unitcast Corp. 240
United-Carr Fastener Corp. 186
United Screw & Bolt Corp..... 16
U.S. Electrical Motors, Inc..... 221
U.S. Graphite Co.....4th Cover, 14–15
U.S. Steel Corp. 36, 60–61
U.S. Steel Export Co.....36, 60–61
U.S. Steel Supply Co. 60–61

Vallorbs Jewel Co. 194
Veeder Root, Inc. 17
Vickers, Inc. 253
Viking Pump Co. 296
Vulcan Electric Co. 302

Wagner Electric Corp. 187
Waldes-Kohinoor, Inc. 223
Wales-Beech Corp. 55
Ward Leonard Electric Co. 174-175
Warner Electric Brake Mfg. Co... 46
Watson-Flagg Machine Co. 296
Weirton Steel Co. 64A
Welco Motors 334
Wesche Electric Co., B. A. 334
Westinghouse Electric Corp. 33, 49, 57, 64D-64E
Wheland Co. 302
Whitney Chain & Mfg. Co..... 64F
Wiegand Co., E. L. 277
Williams Co., J. H..... 300
Wilson Co., H. A..... 78
Wirebound Box Mfgrs. Assoc..... 214
Wisconsin Motor Corp..... 304
Witte Engine Works 332
Wittek Mfg. Co. 304
Wolverine Bolt Co. 55
Worcester Pressed Steel Co..... 64B

■

PROFESSIONAL SERVICES 336

■

SEARCHLIGHT SECTION

(Classified Advertising)

EMPLOYMENT
Positions Vacant 336-7
Positions Wanted 337
Employment Services 337

SPECIAL SERVICES
Contract Work 337
Repairing 337

BUSINESS OPPORTUNITIES
Offered 337

EQUIPMENT
(Used or Surplus New)
For Sale 337

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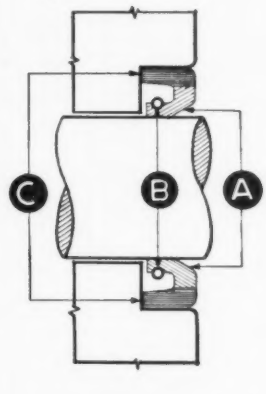

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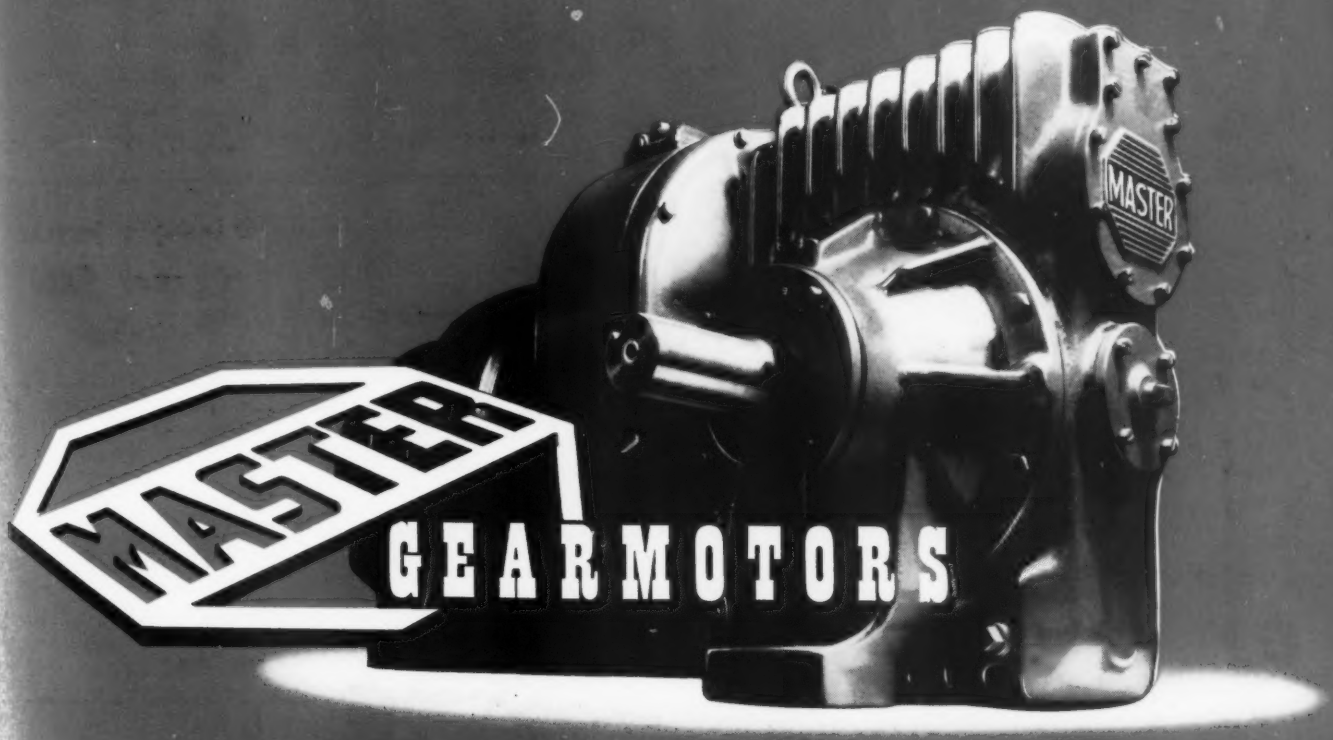

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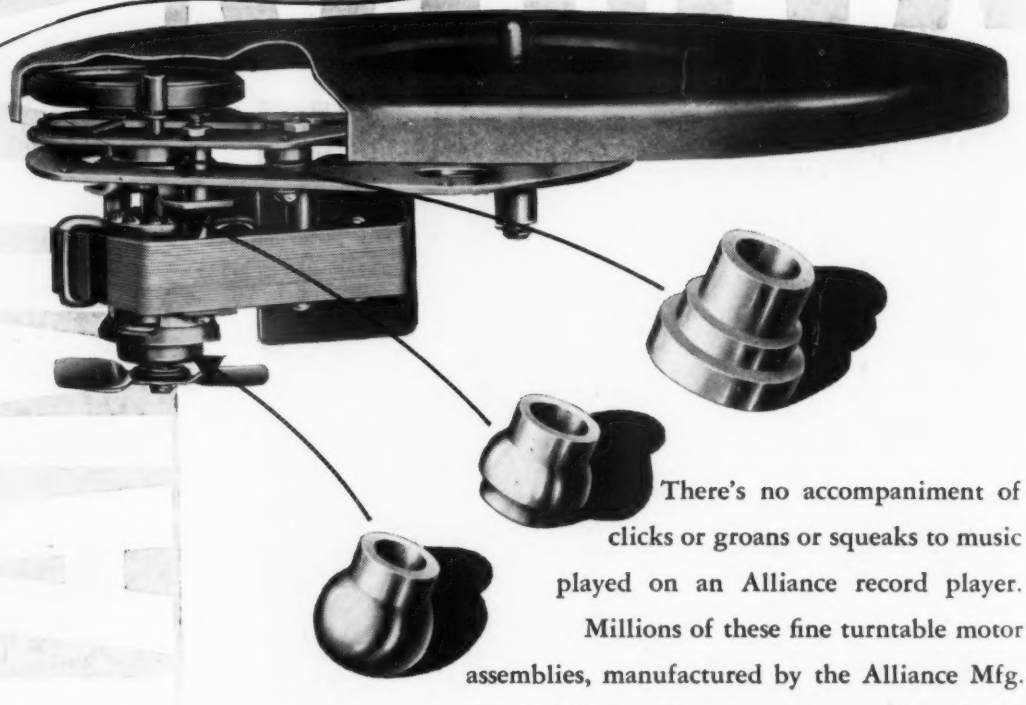
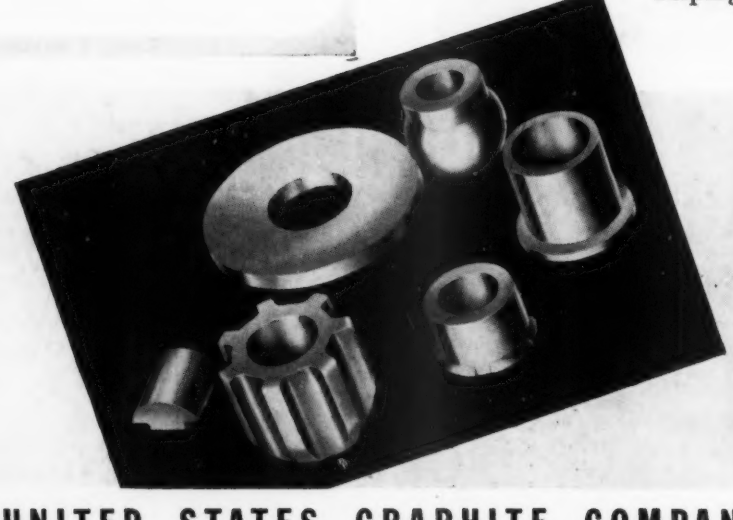
GRAMIX bearings help insure quiet operation of record player



There's no accompaniment of clicks or groans or squeaks to music played on an Alliance record player. Millions of these fine turntable motor assemblies, manufactured by the Alliance Mfg. Co. of Alliance, Ohio, operates *smoothly, silently —and at constant speed*—thanks largely to three little Gramix bearings. Two self-aligning bearings in the motor and a double flange bearing on the main shaft are not only helping Alliance units give better service but they are also helping Alliance cut their cost of manufacture.



Because bearings, gears and other Gramix parts are die-pressed of powdered metal, they cost far less than machined parts, *sometimes as much as 80% less.* And because they can be impregnated with lubricants, further lubrication of Gramix parts is often unnecessary. Our engineers may be able to show how Gramix can help you improve mechanical performance and cut manufacturing costs in your products. Write today for free copy of the 264 page Gramix catalog.

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